Approved afforestation and reforestation baseline and monitoring methodology AR-AM0004

"Reforestation or afforestation of land currently under agricultural use"

(Version 04)

Source

This methodology is based on the draft CDM-AR-PDD "Reforestation around Pico Bonito National Park, Honduras", whose baseline study, monitoring and verification plan and project design document were prepared by the Fundación Parque Nacional de Pico Bonito (FUPNAPIB), Ecologic Development Fund, Winrock International, USAID MIRA and the World Bank (BioCarbon Fund).

For more information regarding the proposal and its consideration by the Executive Board please refer to case ARNM0019: "Reforestation around Pico Bonito National Park, Honduras" on <http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html>.

Section I. Summary and applicability of the baseline and monitoring methodologies

1. Selected baseline approach from paragraph 22 of the CDM A/R modalities and procedures

"Existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary."

2. Applicability

This methodology is applicable to the following project activities:

- Afforestation or reforestation of degraded land, which is subject to further degradation or remains in a low carbon steady state, through assisted natural regeneration, tree planting, or control of pre-project grazing and fuel-wood collection activities (including in-site charcoal production);
- The project activity can lead to a shift of pre-project activities outside the project boundary, e.g. a displacement of agriculture, grazing and/or fuel-wood collection activities, including charcoal production.

The conditions under which the methodology is applicable are:

- Lands to be afforested or reforested are degraded and the lands are still degrading or remain in a low carbon steady state;
- Site preparation does not cause significant longer-term net decreases of soil carbon stocks or increases of non-CO_2 emissions from soil;
- Carbon stocks in soil organic carbon, litter and dead wood can be expected to further decrease due to soil erosion and human intervention or increase less in the absence of the project activity, relative to the project scenario;
- Flooding irrigation is not permitted;

- Soil drainage and disturbance are insignificant, so that non CO_2-greenhouse gas emissions from these types of activities can be neglected;
- The A/R CDM project activity is implemented on land where there are no other on-going or planned A/R activities (no afforestation/reforestation in the baseline).

3. Selected carbon pools

Table A: Selected carbon pools

Carbon Pools	Selected	Justification / Explanation
Above-ground	Yes	Major carbon pool subjected to the project activity
Below-ground	Yes	Major carbon pool subjected to the project activity
Dead wood	No	Conservative approach under applicability condition
Litter	No	Conservative approach under applicability condition
Soil organic carbon	No	Conservative approach under applicability condition

Section II. Baseline methodology description

1. Project boundary

The "project boundary" geographically delineates the afforestation or reforestation project activity under the control of the project participants. The A/R CDM project activity may contain more than one discrete area of land.

Each discrete area of land shall have a unique geographical identification.

It shall be demonstrated that each discrete area of land to be included in the boundary is eligible for an A/R CDM project activity. PPs shall apply the latest version of the tool "Procedures to demonstrate the eligibility of lands for afforestation and reforestation CDM project activities" as approved by the Executive Board.

The latest version of "Guidance on the application of the definition of project boundary to A/R CDM project activities" (available at: <http://cdm.unfccc.int/Reference/Guidclarif>) may be applied in identification of areas of land planned for an A/R CDM project activity.

The project boundary includes emissions sources and gases as listed in Table B.

Table B: Gases considered from emissions by sources other than resulting from changes in carbon pools

Sources	Gas	Included/ excluded	Justification / Explanation
Burning of biomass	CO_2	No	However, carbon stock decreases due to burning are accounted as a carbon stock change
	CH_4	Yes	Non-CO_2 gas emitted from biomass burning
	N_2O	No	Potential emission is negligibly small

2. Eligibility of land

This methodology uses the latest version of the mandatory tool: "Procedures to define the eligibility of lands for afforestation and reforestation project activities" approved by the CDM Executive Board[1] to demonstrate land eligibility within the project boundary.

3. *Ex ante* stratification

If the project activity area is not homogeneous, stratification should be carried out to improve the accuracy and the precision of biomass estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy of the estimates of net GHG removal by sinks.

For estimation of baseline net GHG removals by sinks, or estimation of actual net GHG removals by sinks, strata should be defined on the basis of parameters that are key entry variables in any method (e.g., growth models or yield curves/tables) used to estimate changes in biomass stocks:

- **For baseline net GHG removals by sinks.** It will usually be sufficient to stratify according to area of major vegetation types because baseline removals for degraded (or degrading) land are expected to be small in comparison to project removals;
- **For actual net GHG removals by sinks.** The *ex ante* estimations shall be based on the project planting/management plan. The *ex post* stratification shall be based on the actual implementation of the project planting/management plan. The *ex post* stratification may be affected by natural or anthropogenic impacts if they are able to add variability to growth pattern in the project area, e.g., local fires (see Section III.2).

Further subdivision of the project strata to represent spatial variation in the distribution of the baseline or the project biomass stocks/removals is not usually warranted. However, factors impacting growth (e.g., soil type) might be useful for *ex post* stratification if their variability in the project area is large.

For *ex ante* and ex *post* stratification, PPs may optionally make use of remote sensing data acquired close to the time the project commences and/or close to the time of occurrence of natural or anthropogenic impacts if such impacts add variability to growth pattern in the project area.

Note: In the equations used in this methodology, the letter i is used to represent a stratum and the letter m for the total number of strata.

4. Procedure for selection of most plausible baseline scenario

The baseline scenario is determined by the following steps:

Step 1: Demonstrate that the proposed A/R CDM project activity meets the conditions under which the proposed methodology is applicable, and that baseline approach 22(a) can be used.

Step 2: Define the project boundary as described in Section II.2 above.[2]

---

[1] Hereinafter referred as "A/R eligibility tool" <http://cdm.unfccc.int/Reference/Procedures/index.html>.

[2] As outlined in Section II.1, this methodology uses the latest version of the tool: "Procedures to define the eligibility of lands for afforestation and reforestation project activities" approved by the CDM Executive Board to demonstrate land eligibility within the project boundary.

Step 3: Analyze historical land use, local and sectoral land-use policies or regulations and land use alternatives.

(a) Analyse the historical and existing land-use/land-cover changes in the context of the socio-economic conditions prevailing within the boundary of the proposed A/R CDM project activity and identify key factors that influence the land-use/land-cover changes over time, using multiple sources of data including archives, maps or satellite images of land use/cover data prepared before 31.12.1989 (reforestation) or at least 50 years old (afforestation) and before the start of the proposed A/R CDM project activity, supplementary field investigation, land-owner interviews, as well as studies and data collected from other sources;

(b) Show that historical and current land-use/land-cover change has led to progressive degradation of the land over time including a decrease or steady state at a reduced level of the carbon stocks in the carbon pools. Provide indicators of land degradation and carbon stock decrease/steady state that can be verified and sustain the choice of these indicators using appropriate and credible sources of information, such as scientific literature and studies or data collected in the project area or similar areas;

The historical degradation feature can be indicated by:

1. Vegetation degradation. For example:
    - The land was forest at time points in the past and non-forest at more recent time points;
    - There was a forest at time points in the past, but attempts to re-establish the forest through seeding have failed;
    - There was higher crown cover of non-tree vegetation at time points in the past and lower crown cover at more recent time points.
2. Soil degradation. For example:
    - Lower soil erosion at time points in the past than in more recent time points;
    - Higher soil organic matter content at time points in the past than in more recent time points;
    - Less desertification at time points in the past than in more recent time points.

These indicators do not represent all cases of land degradation but are appropriate for the proposed methodology. Other indicators may be used.

(c) Identify and briefly describe national, local and sectoral land-use policies or regulations adopted before 11 November 2001 that may influence land-use/land-cover change and demonstrate that they do not influence the areas of the proposed A/R CDM project activity (e.g., because the policy does not target this area, or because there are barriers to the policy implementation in this area, etc). If the policies (implemented before 11 November 2001) significantly impact the project area, then the baseline scenario cannot be 'degraded land' and this methodology cannot be used any further;

(d) Identify alternative land uses including alternative future public or private activities on the degraded lands including any similar A/R activity or any other feasible land development activities, that are not in contradiction with the identified local, national and/or sectoral land-use policies and regulations and that could be implemented within the boundary of the proposed A/R CDM project activity. In doing so, use land records,

field surveys, data and feedback from stakeholders, and other appropriate sources;

(e) Demonstrate that land-use/land-cover within the boundary of the proposed A/R CDM project activity would not change and/or lead to further degradation and carbon stock decrease in absence of the proposed project activity, e.g., by assessing the relative attractiveness of alternative land uses in terms of benefits to the local economy and communities' subsistence, consulting with stakeholders for existing and future land use, and identifying barriers for alternative land uses.

If the analyses above indicate for the baseline land use that the land area within the boundary of the proposed A/R CDM project activity is likely to change its current status (i.e. degraded and/or subject to further degradation), then this methodology is not applicable. However, if the analysis shows that a change can only occur as a result of the implementation of the proposed A/R CDM activity, continue with the next step.

Step 4: Stratify the A/R CDM project area as explained in Section II.3 above**.**

Step 5: Determine the baseline land-use/land-cover scenario for each stratum.

Analyse the possibility of self-encroachment of trees[3] under the current conditions by, e.g.:

- Survey and identification of trees growing on site;
- Identification of on-site or external seed pools/sources that may result in natural regeneration;
- Identification of the possibility of seed sprout and growth into trees with the potential height, crown cover and area crossing the threshold values used in the national definition of forest, under the current conditions.

If no, or only sparse, natural regeneration with no potential to become a forest can be identified, continue with Section II.5 below. Otherwise, the proposed A/R CDM project activity is not different from the baseline scenario.[4]

5. Estimation of baseline net GHG removals by sinks

Baseline strata without trees or woody perennials

The baseline net greenhouse gas removals by sinks is the sum of the changes in carbon stocks in the carbon pools within the project boundary that would have occurred in the absence of an A/R CDM project activity. As per the conditions under which the proposed methodology is applicable (described in Section I.2), lands to be afforested or reforested are degraded lands, either abandoned or subjected to pre-project grazing activity or agricultural crop activity, with vegetation having area, crown cover and tree high values below the thresholds used in the national definition of forest, and the lands are still degrading or remaining in a low carbon steady state. For this reason, in all baseline strata where:

[3] A woody perennial with a single main stem or, in the case of coppice, with several stems, having a more or less definite crown (TBRFA 2000).

[4] If pre-existing natural vegetation and natural seed sources can develop and become a forest according to the national definition of forest but the land is not used for the purpose of establishing a forest, the area may still be eligible for A/R CDM project activities and the baseline different from the project scenario (e.g., shifting cultivation areas). However, under such particular circumstances, the development of vegetation should be taken into account as the most likely baseline scenario.

(a) No growing trees or woody perennials exist; and

(b) No trees or other woody perennials will start to grow at any time during the crediting period; or

(c) No trees or other woody perennials will reach the threshold for the national definition of forest due to ongoing cutting and burning cycles that are part of shifting cultivation systems;

The baseline net greenhouse gas removals by sinks are expected to be negative due to ongoing degradation. For these strata the methodology conservatively assumes that baseline net greenhouse gas removals by sinks is zero:

$$C_{BSL} = 0 \text{ for all } t^* \leq t_{cp} \quad \textbf{(1)}$$

where:

C_{BSL} Baseline net greenhouse gas removals by sinks; t CO_2-e

t^* Number of years elapsed since the start of the A/R project activity; yr

t_{cp} Year at which the first crediting period ends; yr

This baseline methodology accounts for above-ground and below-ground biomass only. Therefore, for all strata that do not satisfy the conditions listed above, the baseline net greenhouse gas removals by sinks can be calculated by:

$$C_{BSL} = \Delta C_{B,LB} \quad \textbf{(2)}$$

where:

C_{BSL} Baseline net greenhouse gas removals by sinks; t CO_2-e

ΔC_{BLB} Baseline sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e

Note: Following the guidance contained in paragraph 35 in the report of the EB 42 meeting the living biomass does not contain the biomass of herbaceous vegetation.

Note: In this methodology equation 2 is used to estimate baseline net greenhouse gas removals by sinks for the period of time elapsed between project start (*t=1*) and the year *t=t**, *t** being the year for which baseline net greenhouse gas removals by sinks are estimated.

Estimation of ΔC_{BLB} (changes in living biomass carbon stocks in the baseline)

$$\Delta C_{BLB} = \sum_{t=1}^{t^*} \sum_{i=1}^{m_{BL}} \Delta C_{B,ikt} \quad \textbf{(3)}$$

where:

ΔC_{BLB} Baseline sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e

$\Delta C_{B,ikt}$ Baseline annual carbon stock change in living biomass for stratum *i*, stand model *k*, time *t*; t CO_2-e. yr^{-1}

i 1, 2, 3, … m_{BL} baseline strata

k 1, 2, 3, … *K* stand model

t 1, 2, 3, …*t** years elapsed since the start of the A/R CDM project activity

To be symmetric, equation 3 will be used for both the baseline and the actual net GHG removals by sinks, the subscript *k* referencing stand model is included. Stand model is the term used for stratum within the project. For the *ex ante* baseline estimation $k = 0$.[5]

For those strata without growing trees, or with trees and non-tree vegetation as part of an agricultural cycle that are not accumulating carbon due to the predictable cutting and burning, $\Delta C_{B,ikt} = 0$. For those strata with a few growing trees, $\Delta C_{B,ikt}$ is estimated using one of following two methods that can be chosen based on the availability of data.

Method 1 (Carbon gain-loss method)[6]

$$\Delta C_{ikt} = \Delta C_{G,ikt} - \Delta C_{L,ikt} \qquad (4)$$

where:

ΔC_{ikt} Annual carbon stock change in living biomass for stratum *i,* for stand model *k,* time *t*; t CO_2-e yr^{-1}

$\Delta C_{G,ikt}$ Annual increase in carbon stock due to biomass growth for stratum *i,* for stand model *k,* time *t*; t CO_2-e yr^{-1}

$\Delta C_{L,ikt}$ Annual decrease in carbon stock due to biomass loss for stratum *i,* for stand model *k*, time *t;* t CO_2-e yr^{-1}

Note: This methodology conservatively assumes that $\Delta C_{L,ikt} = 0$ for the baseline scenario.[7]

$$\Delta C_{G,ikt} = A_{ijt} \cdot C_{TOTAL,ikt} \qquad (5)$$

where:

$\Delta C_{G,ikt}$ Annual increase in carbon *stock* due to biomass growth for stratum *i,* for stand model *k,* time *t*; t CO_2-e. yr^{-1}

A_{ijt} Area of stratum *i,* for stand model *k*, at time *t*; hectare (ha)

$C_{TOTAL,ikt}$ Annual average increment rate in total biomass in units of dry matter for stratum *i* for stand model *k*, time *t*; t d.m. ha^{-1} yr^{-1}

Note: The area of a stratum *i* planted with species *j* has a time notation because depending on baseline land-use/land-cover projections stand models *k* may appear at different dates within the same stratum. As well, $G_{TOTALikt}$ can be estimated as a constant annual average value.

The baseline net greenhouse gas removals by sinks can be calculated by:

$$\Delta C_{TOTAL,ikt} = \sum_{j}^{J} G_{w,ijt} \cdot (1 + R_j) \cdot CF_j \cdot \frac{44}{12} \qquad (6)$$

[5] Within a baseline stratum, the vegetation type (=stand model) should be similar as a criterion for stratification.
[6] GPG-LULUCF Equation 3.2.2, Equation 3.2.4 and Equation 3.2.5.
[7] This assumption implies that all baseline woody biomass is assumed to remain living during the entire crediting period. This is conservative because the proportion of living biomass that will die or will be harvested is not deduced from the estimation of baseline net GHG removals by sinks.

$$\Delta G_{w,ijt} = I_{v,ijt} \cdot D_j \cdot BEF_{1,j} \qquad \textbf{(7)}$$

where:

$C_{TOTAL,ikt}$	Annual average increment rate in total biomass for stratum *i* for stand model *k*, time *t*; t d.m. ha^{-1} yr^{-1}
$G_{w,ijt}$	Average annual above-ground biomass increment for stratum *i,* species *j*, at time *t*; t d.m. ha^{-1} yr^{-1}
R_j	Root-shoot ratio appropriate to increments for species *j*; dimensionless
CF_j	The carbon fraction for species *j*; t C (t d.m.)$^{-1}$
$I_{v,ijt}$	Average annual increment in merchantable volume for stratum *i,* species *j*; m^3 ha^{-1} yr^{-1}
D_j	Basic wood density for species *j*; t d.m. m^{-3}
$BEF_{1,j}$	Biomass expansion factor for conversion of annual net increment (including bark) in merchantable volume to total above-ground biomass increment for species *j*; dimensionless

Note:

(i) $G_{TOTALikt}$ can be estimated as a constant annual average value;

(ii) Care *should* be taken that the root-shoot ratio may change as a function of the above-ground biomass present at time (*t*) (see IPCC GPG, 2003, Annex 3.A1, Table 3A1.8);

(iii) I_{vijt} is *estimated* as 'current annual increment – CAI'. The 'mean annual increment' – MAI in the forestry jargon – can only be used if its use leads to conservative estimates.

Method 2 (stock change method[8])

$$\Delta C_{ikt} = \frac{C_{ikt2} - C_{ikt1}}{T} \cdot \frac{44}{12} \qquad \textbf{(8)}$$

$$C_{ikt} = C_{AB,ijt} + C_{BB,ijt} \qquad \textbf{(9)}$$

$$C_{AB,ijt} = A_{ijt} \cdot V_{ijt} \cdot D_j \cdot BEF_{2,j} \qquad \textbf{(10)}$$

$$C_{BB,ijt} = C_{AB,ijt} \cdot R_j \qquad \textbf{(11)}$$

where:

ΔC_{ikt}	Annual carbon stock change in living biomass for stratum *i,* for stand model *k,* time *t*; t CO_2-e. yr^{-1}
C_{ikt}	Carbon stock in living biomass for stratum *i,* stand model *k*, time *t*; t C
C_{ikt2}	Total carbon stock in living biomass for stratum *i,* species *j*, calculated at time $t=t_2$; t C
C_{ikt1}	Total carbon stock in living biomass for stratum *i,* species *j*, calculated at time $t=t_1$; t C
T	Number of years between times t_2 and t_1 $(T = t_2 - t_1)$

[8] GPG-LULUCF Equation 3.2.3.

A_{ikt}	Area of stratum *i*, for stand model *k*, at time *t*; hectare (ha)
$C_{AB,ijt}$	Carbon stock in above-ground biomass for stratum *i,* species *j*, at time *t*; t C
$C_{BB,ijt}$	Carbon stock in below-ground biomass for stratum *i,* species *j*, at time *t*; t C
V_{ijt}	Average merchantable volume of stratum *i,* species *j*, at time *t*; m^3 ha^{-1}
D_j	Basic wood density of species *j*; t d.m. m^{-3} merchantable volume
$BEF_{2,j}$	Biomass expansion factor for conversion of merchantable volume to above-ground tree biomass for species *j*; dimensionless
R_j	Root-shoot ratio for species *j*; dimensionless

Note: Stratification criteria shall include age classes so that V_{ijt} should have low variances within stratum *i,* species *j* and time *t.*

An alternative way of estimating $C_{AB,ijt}$ is to use allometric equations which are also considered to be good practice by the IPCC.

$$C_{AB,ijt} = A_{ikt} \cdot nTR_{ijt} \cdot CF_j \cdot f_j(DBH_t, H_t) \qquad \textbf{(12)}$$

where:

$C_{AB,ijt}$	Carbon stock in above-ground biomass for stratum *i,* species *j*, at time *t;* t C
A_{ikt}	Area of stratum *i,* stand model *k*, at time *t*; hectare (ha)
nTR_{ijt}	Number of trees in stratum *i*, species *j*, at time *t*; dimensionless ha^{-1}
CFj	Carbon fraction for species *j*, t C (t d.m.)$^{-1}$
$f_i(DBH_t,H_t)$	Allometric equation linking above-ground biomass of living trees (d.m. ha^{-1}) to mean diameter at breast height (*DBH*) and possibly mean tree height (*H*) for species *j*; dimensionless

Note: Mean *DBH* and *H* values should be estimated for stratum *i*, species *j*, at time *t* using a growth model or yield table that gives the expected tree dimensions as a function of tree age. The allometric relationship between above-ground biomass and *DBH* and possibly *H* is a function of the species considered.

To be conservative, this methodology does not account for living biomass losses due to harvesting and mortality in the baseline scenario and does account for them in the project scenario. Therefore when using method 2 for the baseline (and make its use consistent with the assumption $\Delta C_{L,ij} = 0$ made in equation 4 of method 1), V_{ijt} shall not consider volume reductions due to harvesting and mortality. For the choice of methods there is no priority, and it will mainly depend on the kind of parameters available. V_{ijt} and $I_{v,itj}$ shall be estimated based on number of trees and national/local growth curve/table that is usually covered by national/local forestry inventory. D_j, $BEF_{1,j}$, $BEF_{2,j}$, CF_j and R_j are regional and species specific and shall be chosen with priority from higher to lower order as follows:

(a) Existing local and species specific;

(b) National and species specific (e.g. from national GHG inventory);

(c) Species specific from neighboring countries with similar conditions. Sometimes (c) might be preferable to (b); this case shall be substantiated in the PDD;

(d) Globally species specific (e.g. GPG-LULUCF).

If none of the above works, then start again from a), but replace 'species specific' with 'similar species' (e.g., shape of trees, broadleaved vs. deciduous etc).

When choosing from global or national databases because local data are limited, it shall be confirmed with any available local data that the chosen values for the baseline are not a significant underestimate of the baseline net removals by sinks, as far as can be judged. Local data used for confirmation may be drawn from the literature and local forestry inventory.

6. Additionality

This methodology uses the latest version of the 'Tool for the demonstration and assessment of additionality in afforestation and reforestation CDM project activities' approved by the CDM Executive Board.[9]

7. *Ex ante* actual net GHG removal by sinks

The actual net greenhouse gas removals by sinks represent the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary, minus the increase in greenhouse emissions by sources measured in CO_2 equivalents within the project boundary that are a result of the implementation of an A/R CDM project activity. Therefore,

$$C_{ACTUAL} = \Delta C_{P,LB} - GHG_E \quad \textbf{(13)}$$

where:

C_{ACTUAL} Actual net greenhouse gas removals by sinks; t CO_2-e

$\Delta C_{P,LB}$ Sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e

GHG_E Sum of the increases in GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity; t CO_2-e

Note: This methodology equation 13 is used to estimate actual net greenhouse gas removals by sinks for the period of time elapsed between project start ($t=1$) and the year $t=t^*$, t^* being the year for which actual net greenhouse gas removals by sinks are estimated.

7.1 Estimation of actual $\Delta C_{P,LB}$ (changes in living biomass carbon stocks in the project scenario)

In general, the changes in living biomass stocks in the project can be given by:

$$\Delta C_{P,LB} = \Delta C_{P,LB_T} - E_{biomassloss} \quad \textbf{(14)}$$

where:

$\Delta C_{P,LB}$ Sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e

$\Delta C_{P,LB\,T}$ Sum of the changes in living tree biomass carbon stocks (above- and below-ground); t CO_2-e

$E_{biomassloss}$ Decrease in the carbon stock in the living biomass carbon pools of non-tree woody vegetation in the year of site preparation, up to time t^*; t CO_2-e

9 Hereinafter referred as 'AR additionality tool' <http://cdm.unfccc.int/Reference/Guidclarif/>

Treatment of pre-existing vegetation

Given the conditions under which the proposed methodology is applicable (described in Section I.3), pre-existing carbon stocks in the living biomass are most likely not significant (< 2% of the anticipated actual net GHG removals by sinks). The methodology nevertheless considers the two following possible situations:

(a) The carbon stocks in the living biomass of pre-existing non-tree and tree vegetation are not significant:

- Carbon stock changes in the living biomass of pre-existing non-tree and tree vegetation are not included in the *ex ante* calculation of actual carbon stock changes, regardless if the pre-existing non-tree and tree vegetation is left standing or is harvested;
- If the pre-existing vegetation is burned for land preparation before planting, non-CO_2 emissions are estimated from the total above-ground biomass (details in Section 2 below) and included in the calculation of actual net GHG removal by sinks if they are significant (> 2% of actual net GHG removals by sinks);
- To be conservative the biomass of the pre-existing vegetation would be set as the maximum biomass over the slash and burn/fallow cycle.

(b) The carbon stocks in the living biomass of pre-existing non-tree and tree vegetation are significant.

If the carbon stocks in the living biomass of pre-existing vegetation are likely to represent more than 2% of the anticipated actual net GHG removals by sinks, the following methodology procedure is applied:

(a) If the baseline is shifting agriculture or another form of agriculture/fallow cycle, a conservative approach of setting the baseline stock to be equal to the maximum stock over the cycle should be used. It is assumed all this stock will disappear in the year of site preparation. The stocks are assumed to be burned:

- Non-CO_2 emissions are calculated from the carbon stock in the above-ground biomass of non-tree and tree vegetation (details in Section 6.2 below);
- 100% carbon stock loss in the above-ground and below-ground biomass is assumed and estimated using equation 15 for both the non-tree component and the young trees.

(b) Otherwise if for land preparation before planting non-tree[10] and tree vegetation is burned (and not harvested) then:

- Non-CO_2 emissions are calculated from the carbon stock in the above-ground biomass of non-tree and tree vegetation (details in Section 7.2.2 below);
- 100% carbon stock loss in the above-ground and below-ground biomass is assumed and estimated using the methods outlined in equation 16 ff. below for the tree component and equation 15 for the non-tree component.

[10] In accordance with guidance contained in paragraph 35 of the EB 42 meeting report, GHG emissions due to removal (loss) of herbaceous vegetation as a component of non-tree biomass are neglected in this methodology. Hence, all references to GHG emission from removal of non-tree vegetation do not include GHG emissions from removal of herbaceous vegetation.

(c) Or, if the tree vegetation is partially or totally harvested before burning then:

- The carbon stock decrease in the harvested above-ground and below-ground tree biomass is estimated using the methods outlined below;
- The above-ground biomass of the harvested trees is subtracted from the total above-ground biomass estimate used for the calculation of non-CO_2 emissions from burning;
- Carbon stock changes in the living biomass (above-ground and below-ground) of pre-existing trees that are left standing are not included in the *ex ante* calculation of actual carbon stock changes. This is a conservative assumption because the trees will continue to grow. *Ex post* these trees will be measured in the monitoring plots; any change in the carbon stocks in these trees due to growth or mortality will be duly accounted.

All existing non-tree vegetation is assumed to disappear in the year of site preparation, to account for slash and burn or future competition from planted trees. This is a conservative assumption because there will be some non-tree vegetation in the project scenario. Some vegetation may re-grow even if all non-tree vegetation is removed during the site preparation (overall site burning). The carbon stock decrease is estimated as follows:

$$E_{biomassloss} = \sum_{t=1}^{t^*}\sum_{i=1}^{m_{BL}}\sum_{k=1}^{K_P} A_{ikt} \cdot B_{pre,ikt} \cdot CF_{pre} \cdot \frac{44}{12} \qquad \textbf{(15)}$$

where:

$E_{biomassloss}$	Decrease in the carbon stock in the living biomass carbon pools of non-tree vegetation in the year of site preparation, up to time t^*; t CO_2-e
A_{ikt}	Area of stratum i, stand model k, time t; ha
$B_{pre,ikt}$	Average pre-existing stock non-tree pre-project biomass on land to be planted before the start of a proposed A/R CDM project activity for baseline stratum i, stand model k, time t; t d.m. ha^{-1}
CF_{pre}	The carbon fraction of dry biomass in pre-existing vegetation, t C (t d.m.)$^{-1}$
i	1, 2, 3, ... m_{BL} strata in the baseline
k	1, 2, 3, … K_P stand models in the project scenario
t	1, 2, 3, ...t^* years elapsed since the start of the A/R project activity

Treatment of trees

For clarification, trees refer to all woody biomass that occurs as a result of the A/R project.

The methodology and equations for estimating *ex ante* actual changes in the living biomass carbon stocks are similar to the ones used for the estimation of baseline changes in the living biomass carbon stocks, with the following main differences:

(a) Harvesting and mortality are taken into account;

(b) Baseline strata (defined based on pre-existing vegetation, among others) differ for the project implementation (based on type of baseline stratum where activity takes place, stand model and possibly cohorts of the same stand model);

(c) Stand models are different as defined in Step 2 of Section II.2.

$$\Delta C_{P,LB_T} = \sum_{t=1}^{t^*} \sum_{i=1}^{m_{BL}} \sum_{k=1}^{K_P} \Delta C_{P,LB,ikt} \quad \textbf{(16)}$$

where:

$\Delta C_{P,LB}$ Sum of the changes in living biomass carbon stocks in the project scenario (above- and below-ground); t CO_2-e

$\Delta C_{LB,ikt}$ Annual carbon stock change in living biomass for stratum *i,* stand model *k*, time *t*; t CO_2-e yr^{-1}

i 1, 2, 3*, ...* m_{BL} strata in the baseline

k 1, 2, 3, … *K* stand models in the project scenario

t 1, 2, 3, ...*t** years elapsed since the start of the A/R project activity

Annual carbon stock changes in the living biomass ($\Delta C_{LB,ikt}$) are estimated using one of the two methods described in Section II.5. In addition:

Method 1 (Carbon gain-loss method)[11]

The following equations shall be used to calculate the average annual decrease in carbon stocks due to biomass loss for stratum *i,* stand model *k* and time *t* ($\Delta C_{L,ikt}$)

$$\Delta C_{L,ikt} = L_{hr,ikt} + L_{fw,ikt} + L_{ot,ikt} \quad \textbf{(17)}$$

where:

$\Delta C_{L,ikt}$ Average annual decrease in carbon stocks due to biomass loss for stratum *i*, stand model *k*, time *t*; t CO_2-e yr^{-1}

$L_{hr,ikt}$ Annual carbon loss due to commercial harvesting for stratum *i*, stand model *k*, time *t*; t CO_2-e yr^{-1}

$L_{fw,ikt}$ Annual carbon loss due to fuel wood gathering for stratum *i*, species *j*, time *t*; CO_2-e yr^{-1}

$L_{ot,ikt}$ Annual natural losses (mortality) of carbon for stratum *i*, species *j*, time *t*; CO_2-e yr^{-1}

and:

$$L_{hr,ikt} = A_{ikt} \cdot \sum_{j=1}^{J} H_{ijt} \cdot D_j \cdot BEF_{2,j} \cdot CF_j \cdot \frac{44}{12} \quad \textbf{(18)}$$

$$L_{fw,ikt} = A_{ijt} \cdot \sum_{j=1}^{J} FG_{ijt} \cdot D_j \cdot BEF_{2,j} \cdot CF_j \cdot \frac{44}{12} \quad \textbf{(19)}$$

$$L_{ot,ikt} = Adist_{ikt} \cdot \sum_{j=1}^{J} B_{w,j} \cdot M_{ijt} \cdot CF_j \cdot \frac{44}{12} \quad \textbf{(20)}$$

[11] Refers to GPG-LULUCF Equation 3.2.6, Equation 3.2.7, Equation 3.2.8 and Equation 3.2.9.

where:

$L_{hr,ikt}$	Annual carbon loss due to commercial harvesting for stratum *i*, stand model *k*, time *t*; t CO_2-e yr^{-1}
$L_{fw,ikt}$	Annual carbon loss due to fuel wood gathering for stratum *i*, species *j*, time *t*; CO_2-e yr^{-1}
$L_{ot,ikt}$	Annual natural losses (mortality) of carbon for stratum *i*, species *j*, time *t*; CO_2-e yr^{-1}
j	1,2,3,…*J* tree species
H_{ijt}	Annually extracted merchantable volume for stratum *i,* species *j*, time *t*; m^3 ha^{-1} yr^{-1}
D_j	Wood density for species *j*; t d.m. m^{-3} merchantable volume
$BEF_{2,j}$	Biomass expansion factor for converting merchantable volumes of extracted round wood to total above-ground biomass (including bark) for stratum *i,* species *j*, time *t*; dimensionless
CF_j	Carbon fraction of dry matter for species *j*; t C (t d.m.)$^{-1}$
FG_{ijt}	Annual volume of fuel wood harvesting for stratum *i,* species *j*, time *t*; m^3 ha^{-1} yr^{-1}
A_{ikt}	Area of stratum *i,* stand model *k*, at time *t*; hectare (ha)
$Adist_{ikt}$	Forest areas affected by disturbances in stratum *i,* stand model *k*, time *t*; ha yr^{-1}
$B_{w,ijt}$	Average above-ground biomass stock for stratum *i,* species *j*, time *t*; t d.m. ha^{-1}
M_{ijt}	% Mortality caused by disturbance in stratum *i,* species *j*, time *t*; dimensionless

Note: The time notation *t* is given here assuming that in most cases project participants are able to define a harvesting schedule (volumes and years of harvesting as per Step 2 in Section II.2). The use of a constant average annual harvesting volume should be used only under particular circumstances and should be justified in the PDD.

This methodology allows for the assumption of no disturbances in the *ex ante*[12] estimation of actual net GHG removals by sinks, which implies that $Adist_{ikt}$ is set as zero and therefore $L_{ot,ikt} = 0$. This assumption can be made in project circumstances where expected disturbances (e.g. fire, pest and disease outbreaks) are of low frequency and intensity, and therefore difficult to predict. However, the factor $Adist_{ikt}$ should be estimated when natural tree mortality due to competition and/or disturbances is likely to cause significant carbon losses. In such cases, $Adist_{ikt}$ can be estimated as an average annual percentage of A_{ikt} to express a yearly mortality percentage due to competition (usually between 0% and 2% of A_{ikt}) or disturbances.

Method 2 (stock change method)[13]

The 'stand models' as defined in Section II.3, Step 2 shall be developed and presented in the PDD in a way that the values of V_{ikjt} (average merchantable volume of stratum *i,* species *j*, stand model *k*, at time *t*) used in equation 10 represent the actual average merchantable volume of stratum *i,* species *j*, stand model *k*, at time *t* after deduction of harvested volumes and mortality:

$$V_{ikt2} = V_{ikt1} \cdot (1 - Mf_{ikT}) + \sum_{j=1}^{J_k} (I_{v,ijT} - H_{ijT} - FG_{ijT}) \cdot T \quad \textbf{(21)}$$

12 *Ex post* monitoring of disturbances will not be necessary, as the effect of disturbances in carbon stocks will be captured through the monitoring of permanent sample plots.

13 GPG-LULUCF Equation 3.2.3.

$$Mf_{ikT} = \left(\frac{Adist_{ikT}}{A_{ikT}} \right) \quad \textbf{(22)}$$

where:

V_{ikt1}	Average merchantable volume of stratum *i,* stand model *k*, at time $t = t_1$; $m^3\ ha^{-1}$
V_{ikt2}	Average merchantable volume of stratum *i,* stand model *k*, at time $t = t_2$; $m^3\ ha^{-1}$
Mf_{ikT}	Mortality factor = percentage of V_{ikt1} died during the period *T*; dimensionless
$I_{v,ijT}$	Average annual net increment in merchantable volume for stratum *i,* species *j* during the period *T*; $m^3\ ha^{-1}\ yr^{-1}$
H_{ijT}	Average annually harvested merchantable volume for stratum *i,* species *j*, during the period *T*; $m^3\ ha^{-1}\ yr^{-1}$
FG_{ijT}	Average annual volume of fuel wood harvested for stratum *i,* species *j*, during the period *T*; $m^3\ ha^{-1}\ yr^{-1}$
T	Number of years between times t_2 and t_1 $(T = t_2 - t_1)$
$Adist_{ijT}$	Average annual area affected by disturbances for stratum *i,* species *j*, during the period *T*; $ha\ yr^{-1}$
A_{ijT}	Average annual area for stratum *i,* species *j*, during the period *T*; $ha\ yr^{-1}$
j	1,2,3…J_k tree species in stand model *k*

The choices of methods and parameters shall be used in the same ways as described in Section II.5.

7.2 Estimation of GHG_E (increase in GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity)

An A/R CDM project activity may increase GHG emissions, in particular CO_2, CH_4 and N_2O. The list below contains factors that may be attributable to the increase of GHG emissions:[14]

- Emissions of greenhouse gases by biomass burning from site preparation (slash and burn activity).

The increase in GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary can be estimated by:

$$GHG_E = E_{BiomassBurn} \quad \textbf{(23)}$$

where:

GHG_E	Increase in GHG emissions as a result of the implementation of the proposed A/R CDM project activity within the project boundary; t CO_2-e
$E_{BiomassBurn}$	Increase in GHG emission as a result of biomass burning within the project boundary; t CO_2-e

Note: In this methodology equation 23 is used to estimate the increase in GHG emissions for the period of time elapsed between project start (*t=1*) and the year *t=t*, t** being the year for which actual net greenhouse gas removals by sinks are estimated.

[14] Refer to Box 4.3.1 and Box 4.3.4 in IPCC GPG-LULUCF.

7.2.1 Estimation of $E_{BiomassBurn}$ (GHG emissions from biomass burning)

Slash and burn occurs traditionally in some regions during site preparation before planting and/or replanting, and this practice results in CO_2 and non-CO_2 emissions. Based on revised IPCC 1996 Guideline for LULUCF, this type of emissions can be estimated (whenever double counting of carbon stock losses is avoided) as follows.

$$E_{BiomassBurn} = E_{BiomassBurn,CO_2} + E_{BiomassBurn,CH_4} \quad \textbf{(24)}$$

where:

$E_{BiomassBurn}$	Total GHG emission from biomass burning in slash and burn; t CO_2-e
$E_{BiomassBurn,CO2}$	CO_2 emission from biomass burning in slash and burn; t CO_2-e
$E_{BiomassBurn,\ CH4}$	CH_4 emission from biomass burning in slash and burn; t CO_2-e

and:

$$E_{BiomassBurn,CO_2} = \sum_{t=1}^{t^*}\sum_{i=1}^{S_{PS}}\sum_{k=1}^{K}(A_{B,ikt\_sb} \cdot B_{ikt} \cdot PBB_{ikt} \cdot CE \cdot CF) \cdot \frac{44}{12} \quad \textbf{(25)}$$

where:

$E_{BiomassBurn,CO2}$	CO_2 emission from biomass burning in slash and burn; t CO_2-e
A_{B,ikt_sb}	Area of slash and burn for stratum *i*, stand model *k*, time *t*; ha
B_{ikt}	Average above-ground biomass stock before burning for stratum *i* as determined for the respective baseline stratum, stand model *k*, time *t*; t d.m. ha^{-1}
PBB_{ikt}	Average proportion of biomass burnt for stratum *i*, stand model *k*, time *t*; dimensionless
CE	Average biomass combustion efficiency (IPCC default = 0.5); dimensionless
CF	Carbon fraction (IPCC default = 0.5); t C (t d.m.)$^{-1}$
i	1, 2, 3, ... S_{PS} strata of the project activity
k	1, 2, 3, … *K* stand models in the project scenario
t	1, 2, 3, ...*t** years elapsed since the start of the A/R project activity

Emissions of non-CO_2 gases are given by:[15]

$$E_{BiomassBurn,CH_4} = E_{BiomassBurn,CO_2} \cdot \frac{12}{44} \cdot ER_{CH_4} \cdot \frac{16}{12} \cdot GWP_{CH_4} \quad \textbf{(26)}$$

where:

$E_{BiomassBurn,CO2}$	CO_2 emission from biomass burning in slash and burn; t CO_2-e
$E_{BiomassBurn,\ CH4}$	CH_4 emission from biomass burning in slash and burn; t CO_2-e

15 Refers to Table 5.7 in 1996 Revised IPCC Guideline for LULUCF and Equation 3.2.19 in IPCC GPG-LULUCF.

ER_{CH4}	Emission ratio for CH_4 (IPCC default value = 0.012); t CO_2-e/t C
GWP_{CH4}	Global Warming Potential for CH_4 (= 21 for the first commitment period); tCO_2-e./t CH_4

The combustion efficiencies *CE* may be chosen from Table 3.A.14 of IPCC GPG-LULUCF. If no appropriate combustion efficiency can be used, the IPCC default of 0.5 should be used. The nitrogen-carbon ratio (N/C ratio) is approximated to be about 0.01. This is a general default value that applies to leaf litter, but lower values would be appropriate for fuels with greater woody content, if data are available. Emission factors for use with above equations are provided in Tables 3.A.15 and 3.A.16 of IPCC GPG-LULUCF.

8. Leakage

Leakage (*LK*) represents the increase in GHGs emissions by sources which occurs outside the boundary of an A/R CDM project activity which is measurable and attributable to the A/R CDM project activity. According to the guidance provided by the Executive Board, leakage also includes the decrease in carbon stocks which occurs outside the boundary of an A/R CDM project activity which is measurable and attributable to the A/R CDM project activity (see EB 22, Annex 15).

There are three sources of the leakage covered by this methodology:

- Carbon stock decreases caused by displacement of pre-project agricultural crops, grazing and fuel-wood collection activities;
- Carbon stock decreases caused by the increased use of wood posts for fencing.

$$LK = LK_{ActivityDisplacement} \quad \textbf{(27)}$$

Note: In this methodology, equation 27 is used to estimate leakage for the period of time elapsed between project start (*t=1*) and the year *t=t*, t** being the year for which actual net greenhouse gas removals by sinks are estimated.

8.1 Estimation of $LK_{ActivityDisplacement}$ (leakage due to activity displacement)

The land planned for A/R CDM activities may be subjected to agricultural activities, grazing and fuel-wood collection. Thus, as the result of the project activity, these pre-project activities may be temporarily or permanently displaced from within the project boundary to areas outside the project boundary. The displacement may result in leakage if new agricultural or grazing areas are obtained by converting stocked areas, particularly forests, to new areas for agricultural or grazing activities or if the displaced fuel-wood collection results in degradation or deforestation of forests and devegetation of other lands.

For project activities involving grazing, if net livestock is not increased, CO_2 emissions resulting from fodder consumption and CH_4 emissions from enteric fermentation in displaced domestic livestock do not represent an overall net increase of GHG emissions attributable to the A/R CDM project activity because they would occur in the without project scenario.[16] These sources can be excluded from the leakage calculations.

Taking into account the above, leakage due to activity displacement is estimated as follows:

$$LK_{Activitydisplacement} = LK_{conversion} + LK_{fuelwood} \quad \textbf{(28)}$$

[16] See Decision EB22, Annex 15 <http://cdm.unfccc.int/EB/Meetings/022/eb22_repan15.pdf>.

where:

$LK_{ActivityDisplacement}$	Leakage due to activity displacement; t CO_2-e
$LK_{conversion}$	Leakage due to conversion of forest to non-forest; t CO_2-e
$LK_{fuel\text{-}wood}$	Leakage due to the displacement of fuel-wood collection; t CO_2-e

8.1.1 Estimation of $LK_{conversion}$ (Leakage due to conversion of lands)

As a result of the A/R CDM project activity, agricultural activities may be displaced permanently or temporarily outside the project boundary. This 'activity shifting' or 'activity displacement' may result in leakage in the immediate years after the start of the project activity when activities are displaced to areas outside the project boundary. $LK_{conversion}$ occurs in two ways:

(a) Conversion for grazing; and

(b) Conversion for cropland.

Therefore:

$$LK_{conversion} = LK_{conv-graz} + LK_{conv-crop} \quad (29)$$

where:

$LK_{conv\text{-}graz}$	Leakage resulting from the conversion for grazing
$LK_{conv\text{-}crop}$	Leakage resulting from the conversion for cropland

8.1.2 Estimation of $LK_{conv\text{-}graz}$ (Leakage due to conversion of land to grazing land)

Depending on the specific project circumstances, the entire pre-project animal population, or a fraction of it, may have to be displaced permanently, or temporarily, outside the project boundary. This displacement of animal populations may result in leakage. However, leakage due to conversion of land to grazing land is not attributable to the A/R CDM project activity if the conversion of land to grazing land occurs 5 or more years after the last measure taken to reduce animal populations in the project area.[17] The type and schedule of the measures to be taken to control animal grazing in the project areas should therefore be described in the AR-CDM-PDD and its implementation monitored.

Where pre-project grazing activities exist, it is necessary to estimate the pre-project animal population from different livestock groups in the project area. This can be done by interviewing the animal owners in the project area or, by interviewing a sample of them in case of multiple landowners or by conducting a Participatory Rural Appraisal (PRA). Other sources of information, such as local animal census data, may also be used. As animal numbers may fluctuate over time, it is recommended to calculate the average animal population of the 5 to 10 years time period preceding the starting date of the A/R CDM project activity.

$$Na_{BL} = \frac{sNa_{BL}}{SFR_{PAga}} \quad (30)$$

[17] A measure to reduce animal population in the project area is a measure taken to avoid grazing in the project area (e.g. fencing). Such measures can result in leakage. The methodology assumes that leakage occurs only once, immediately after the implementation of the measure. This is consistent with baseline approach 22(a), whereby the historical or current population of grazing animals is assumed to be the baseline situation. However, to be on the safe side, the methodology requires monitoring leakage for 5 years following the date of implementation of the measure taken to avoid grazing in the project area.

where:

Na_{BL} Average pre-project number of animals from the different livestock groups that are grazing in the project area; dimensionless

sNa_{BL} Sampled pre-project number of animals from the different livestock groups that are grazing in the project area; dimensionless

SFR_{PAga} Fraction of total project area sampled for animal grazing; dimensionless

Given the conditions under which this methodology is applicable (see Section I.3), particularly the applicability of baseline approach 22(a), the methodology assumes that the estimated historical or current animal population size (Na_{BL}) will remain constant over the entire crediting period.

Based on the planned afforestation or reforestation establishment schedule and the prescribed management, the periods of time from which grazing should be excluded from different parcels to be planted can be specified. This planning should be used to estimate the animal population that will be displaced each year outside the project boundary.

$$Na_{outside,t} = Na_{BL} - Na_{AR,t} \quad \textbf{(31)}$$

where:

$Na_{outside,t}$ Number of animals displaced outside the project area at year t; dimensionless

Na_{BL} Average number of animals from the different livestock groups that are grazing in the project area under the baseline scenario; dimensionless

$Na_{AR,t}$ Number of animals allowed in the project area under the proposed A/R CDM project activity at year t; dimensionless

Case 1: $Na_{BL} < Na_{AR,t}$

Leakage due to the displacement of animal grazing can be set as zero if the number of animals allowed in the project area under the proposed A/R CDM project is more than the average number of animals from the different livestock groups that are grazing in the project area under the baseline scenario.

$$L_{conv\text{-}graz} = 0, \text{ if } Na_{BL} < Na_{AR,t} \quad \textbf{(32)}$$

This situation can only occur if the planned A/R CDM project activity produces more fodder than the baseline activity.

Case 2: $Na_{BL} > Na_{AR,t}$

If the planned A/R CDM project activity produces less fodder than the baseline activity then, the animal populations will be displaced outside the project boundary due to the implementation of the A/R CDM project activity. These animals can be relocated in three different types of grazing areas:

- Existing grazing land areas under the control of the animal owners that are either sub-utilized or that have a potential to be managed for higher fodder production. These areas may be managed in a way that would provide sufficient fodder to feed the entire displaced animal population and prevent leakage. Any such measures have to be described in the PDD and subjected to monitoring. Such measures may not cause a significant increase in GHG emissions;
- New grazing land areas under the control of the animal owners, to be obtained from

conversion of other land-uses to grazing land. This conversion is a source of leakage that should be estimated *ex ante* and monitored *ex post*;

- Unidentifiable grazing land areas, not under the control of the animal owners, which can either already exist or have to be established by converting other land-uses to new grazing land. This is typically the case when the animals are sold as a consequence or the implementation of the A/R CDM project activity.

The total area of grazing land in which the displaced animal population will be maintained can be estimated as follow:

$$GLA = EGL + NGL + XGL \qquad \textbf{(33)}$$

where:

GLA	Total grazing land area outside the project boundary needed to feed the displaced animal populations; ha
EGL	Total existing grazing land area outside the project boundary that is under the control of the animal owners (or the project participants) and that will receive part of the displaced animal populations, up to time t^*, ha
NGL	Total new grazing land area outside the project boundary to be converted to grazing land that is under the control of the animal owners (or the project participants) and that will receive another part of the displaced animal populations, up to time t^*; ha
XGL	Total unidentifiable grazing land area outside the project boundary that will receive the remaining part of displaced animal populations, e.g. when the pre-project animal owners decide to sell the animals, up to time t^*; ha

The following steps are required:

Step 1: Collect data on type of domestic species, their owners, population size, and number of months per annum during which animals from the different species are present in different discrete parcels of the area to be afforested or reforested. If several parcels of land are to be planted, collect these data from a sample. The sample size should not be less than 10% of the randomly selected parcels or 30 parcels. Estimate the annual biomass consumption of the animals over the project area to be planted as follows:

$$\Delta C_{L\,PAt} = \sum_{p=1}^{P} \sum_{an=1}^{An} DBI_{an} \cdot n_{pgt} \cdot a_{gp} \cdot 30 \cdot 0.001 \cdot \frac{1}{SFR_{PAga}} \qquad \textbf{(34)}$$

where:

$\Delta C_{L\,PA,t}$	Annual animal biomass consumption over the project area to be planted at time t; t d.m. yr^{-1}
p	Parcel index (P = total number of parcels); dimensionless
an	Animal type index (An = total number of animal types); dimensionless
DBI_j	Daily biomass intake by animal type j; kg d.m. $head^{-1}$ day^{-1}
n_{pgt}	Number of individual animals from the livestock group g at parcel p at time t; dimensionless

a_{gp} Number of months per annum during which animals from the livestock group *g* are present at parcel *p*; dimensionless

30 Average number of days in month; dimensionless

SFR_{PAga} Fraction of total project area sampled for animal grazing; dimensionless

For data on daily biomass intake, preferably use local data or applicable data from the scientific literature. For default data on daily biomass intake by animal see Table C.

Step 2: Interview the owners of the animal populations identified in Step 1 to identify:

(a) *Na*: the total number of animals from the different livestock groups that are grazing in the project area (or in the sampled discrete parcels); dimensionless;

(b) Na_s: the number of animals from the different livestock groups that the animal owners *intend* to sell as a consequence of the project implementation. Selling may be due to insufficient land under the control of the animal owners outside the project boundary; dimensionless;

(c) *EGL*: the existing grazing land areas outside the project boundary that are under the control of the animal owners and that will be used to maintain part of the displaced *animal* populations; ha. These areas shall be specified in the AR-CDM-PDD and subject to monitoring;

Table C: Approximate values of daily biomass intake (d.m. – dry mass) for different types of animals

Animal Type	Developed / Developing	Daily Feed Intake (MJ head^{-1} day^{-1})	Daily Biomass Intake (kg d.m. head^{-1} day^{-1})
Sheep	Developed Countries	20	2.0
	Developing Countries	13	1.3
Goats	Developed Countries	14	1.4
	Developing Countries	14	1.4
Mules/Asses	Developed Countries	60	6.0
	Developing Countries	60	6.0
Sources: Feed intake from Crutzen *et al.* (1986).			

(d) *NGL*: the new grazing land areas outside the project boundary that are under the control of the animal owners and that will be converted to grass-land to maintain another part of the displaced animal populations; ha. These areas shall be specified in the AR-CDM-PDD and subject to monitoring.

Step 3: Estimate the number of animals that can be displaced in *EGL*-areas:

(a) Interview local experts and the owners of *EGL* areas about maximum population and number of months per annum during which animals of the type displaced can be present

in these areas. Using equation 34, calculate the maximum annual biomass that these grazing areas can produce for animal feeding (ΔC_{Lmax});

(b) Collect data on domestic species, their population, and number of months per annum during which animals from different species are already present in different discrete parcels of the areas identified in Step 2. Using equation 34, calculate the annual biomass that these grazing areas are currently producing for animal feeding ($\Delta C_{Lcurrent}$). The average number of animals already present in the *EGL* areas selected for monitoring shall be specified in the AR-CDM-PDD ($Na_{EGl,t=1}$);

(c) Determine if the *EGL* areas are sufficient for feeding the entire population of displaced animals;

- If: $(\Delta C_{Lmax} - \Delta C_{Lcurrent})_{EGL} \geq \Delta C_{L\,PA}$
  Then: Leakage due to activity displacement is set as zero (e.g. $LK_{conversion} = 0$) and no further-assessment of $LK_{conversion}$ will be necessary;

- If: $(\Delta C_{Lmax} - \Delta C_{Lcurrent})_{EGL} < \Delta C_{L\,PA}$

  Then: Additional grazing areas will be required to feed the displaced animals.

(d) Calculate the number of displaced animals that can be maintained in *EGL* areas as follows:

- Average annual biomass consumed by one average animal:

$$\Delta C_{av} = \Delta C_{LPAt} \cdot \frac{SFR}{NA} \qquad \textbf{(35)}$$

- Number of animals that can be displaced in *EGL*:

$$dNa_{EGL} = \frac{(\Delta C_{L\max} - \Delta C_{Lcurrent})_{EGL}}{\Delta C_{av}} \qquad \textbf{(36)}$$

Step 4: Estimate the number of animals that can be displaced in *NGL*-areas:

(a) Interview local experts and the owners of these areas about maximum population and number of months per annum during which animals can be present in these areas – after conversion to grazing land - for each type of animal species. Using equation 35 calculate the maximum annual biomass that these areas to be converted to grazing lands can produce for animal feeding (ΔC_{Lmax});

(b) Do sub-step b) as in Step 1, but for the *NGL* area. The average number of animals already present in the *NGL* areas selected for monitoring shall be specified in the AR-CDM-PDD ($Na_{NGL,t=1}$);

(c) Determine if the *NGL* areas are sufficient for feeding the population of displaced animals that cannot be maintained in *EGL* areas:

- If: $(\Delta C_{Lmax} - \Delta C_{Lcurrent})_{EGL} + (\Delta C_{Lmax} - \Delta C_{Lcurrent})_{NGL} \geq \Delta C_{L\,PA}$

  Then: *NGL* areas are sufficient and no animals will have to be displaced to unidentifiable areas, and *XGL* can be set as zero;

- If: $(\Delta C_{Lmax} - \Delta C_{Lcurrent})_{EGL} + (\Delta C_{Lmax} - \Delta C_{Lcurrent})_{NGL} < \Delta C_{L\,PA}$

Then: *NGL* areas are insufficient, and some animals will have to be displaced to unidentifiable areas.

(d) Do sub-step d) as in Step 1, but for *NGL* areas.

Step 5: Estimate the number of animals that will have to be displaced to unidentifiable areas and estimate *XGL*:

(a) Determine the number of animals to be displaced to unidentifiable areas using the following conservative decision rule:

- If: $Na_s \geq (Na - dNa_{EGL} + dNa_{NGL})$

  Then: $dNa_{XGL} = Na_s$

- If: $Na_s < (Na - dNa_{EGL} + dNa_{NGL})$

  Then: $dNa_{XGL} = (Na - dNa_{EGL} + dNa_{NGL})$

(b) Calculate *XGL* using the following equation:

$$XGL = A \cdot \frac{dNa_{XGL}}{Na} \tag{37}$$

where:

XGL	Total unidentified grazing land area outside the project boundary that will receive the remaining part of displaced animal populations, e.g. when the pre-project animal owners decide to sell the animals, up to time *t**; ha
A	Total project area; ha
Na	Total number of animals from the different livestock groups that are grazing in the project area; dimensionless
dNa_{XGL}	Total number of animals to be displaced to unidentifiable areas; dimensionless

Step 6: Estimate leakage due to displacement of grazing activities as follows:

$$LK_{conv\text{-}graz} = LK_{NGL} + LK_{XGL} \tag{38}$$

where:

$LK_{conv\text{-}graz}$	Leakage due to conversion of non-grassland to grassland; t CO_2-e
LK_{NGL}	Leakage due to conversion of non-grassland to grassland in *NGL* areas under the control of the animal owners; t CO_2-e
LK_{XGL}	Leakage due to conversion of non-grassland to grassland in unidentified *XGL* areas; t CO_2-e

(a) Estimation of LK_{NGL}

- Stratify *NGL* areas in categories of land-use/land-cover that are significantly different in terms of carbon stock (e.g., crop-land, fallow land, mature forest);
- Estimate the mean carbon stocks in the five carbon pools (from IPCC GPG-LULUCF, literature or original measurements) of each *NGL* stratum. In the case of the soil organic carbon pool, always subtract from the estimate in the *NGL*

strata the estimated mean carbon stock in the soil organic carbon pool of the project area (from IPCC GPG-LULUCF, literature or original measurements). This is not necessary for dead wood and litter, because in the project area, under the applicability conditions of this methodology, these pools have very small carbon stocks;

- If a significant proportion of the above-ground biomass in the *NGL* strata is merchantable timber volume, estimate the biomass of this volume (trough field measurements);
- Subtract from the total above-ground biomass in the *NGL* strata the biomass of the harvested timber and any woody biomass that is likely to be used as fuel-wood or for charcoal production;
- Assume that the remaining above-ground biomass will be 100% burned, which will result in emissions of non-CO_2 gases. If no estimates of harvested timber volume and/or fuel wood biomass are made, assume that all above-ground biomass will be burned. This assumption is conservative because the fraction of biomass that burns is always less than 100%;
- Estimate LK_{NGL} as follows:

$$LK_{NGL} = \sum_{t=1}^{t^*} \left(ngl_t \cdot C_{NGL\,ac_t} + E_{ac_{BiomassBurn\,t}} \cdot (1 - WB_{ht}) \right) \quad \textbf{(39)}$$

where:

LK_{NGL}	Leakage due to conversion of non-grassland to grassland; t CO_2-e
ngl_t	Total area converted to grassland[18] at time *t*; ha
$C_{NGLac\,t}$	Mean carbon stock including above and below-ground biomass of the *NGL* area converted to grassland at time *t*; CO_2-e
WB_{ht}	Fraction of total above-ground biomass harvested as timber and as fuel-wood at time *t* (not burned); dimensionless
$E_{acBiomassBurnt}$	Total non-CO_2 emissions from biomass burning in land converted to grazing land at time *t* (calculated from 100% of the above-ground biomass); t CO_2-e. These can be calculated using equation 23

- Calculate the average aLKNGL per displaced animal in NGL areas as follows:

$$aLK_{NGL} = \frac{LK_{NGL}}{dNa_{NGL}} \quad \textbf{(40)}$$

[18] It is possible that not all *NGL* areas will be converted to grazing land in the first project year; ngl_t shall be estimated as a proportion of the area annually afforested or reforested. The proportion shall be calculated as the ratio *NGL* relative to (*EGL+NGL+XGL*).

where:

aLK_{NGL}	Average leakage due to conversion of non-grassland to grassland per displaced animal in *NGL* areas; t CO_2-e $animal^{-1}$
LK_{NGL}	Leakage due to conversion of non-grassland to grassland; t CO_2-e
dNa_{NGL}	Total number of animals to be displaced to *NGL* areas; dimensionless

(b) Estimation of LK_{XGL}

- As it is not possible to identify land-use/land-cover in *XGL* areas, this methodology conservatively assumes that these areas are covered by mature forests and that these forests will be converted to grazing land;
- Estimate the mean carbon stocks in the five carbon pools (from IPCC GPG-LULUCF, literature or original measurements) of mature forests in the country or region where the grazing animals will most likely be sold. In the case of the soil organic carbon pool, always subtract from the estimate in the *XGL* areas the estimated mean carbon stock in the soil organic carbon pool of the project area (from IPCC GPG-LULUCF, literature or original measurements). This is not necessary for dead wood and litter, because in the project area, under the applicability conditions of this methodology, these pools have very small carbon stocks;
- Estimate the likely percentage of above-ground biomass that is likely not to be burned (from literature or original studies). If no justifiable assumption can be made regarding this percentage, assume 100% of biomass burning;
- Estimate LK_{XGL} as follows:

$$LK_{XGL} = \sum_{t=1}^{t^*} \left(xgl_t \cdot C_{XGL\,ac_t} + E_{ac_{BiomassBurn\ t}} \cdot (1 - WB_{ht}) \right) \qquad \textbf{(41)}$$

where:

LK_{XGLL}	Leakage due to conversion of unidentifiable-land to grassland; t CO_2-e
xgl_t	Total unidentifiable area converted to grassland[19] at time *t*; ha
$C_{XGLac\ t}$	Mean carbon stock including above and below-ground biomass of the *XGL* area converted to grassland at time *t*; CO_2-e
WB_{ht}	Fraction of total above-ground biomass not-burned at time *t* (not burned); dimensionless
$E_{acBiomassBurnt}$	Total non-CO_2 emissions from biomass burning in unidentifiable land converted to grazing land at time *t* (assuming 100% burning of above-ground biomass); t CO_2-e. These can be calculated using equation 23

- Calculate the average aLK_{XGL} per displaced animal in *XGL* areas as follows:

[19] It is possible that not all *XGL* areas will be converted to grazing land in the first project year; ngl_t shall be estimated as a proportion of the area annually afforested or reforested. The proportion shall be calculated as the ratio *XGL* relative to (*EGL*+*NGL*+*XGL*).

$$aLK_{XGL} = \frac{LK_{XGL}}{dNa_{XGL}} \quad \textbf{(42)}$$

where:

aLK_{XGL}	Average leakage due to conversion of non-grassland to grassland per displaced animal in *XGL* areas; t CO_2-e animal^{-1}
LK_{XGL}	Leakage due to conversion of non-grassland to grassland; t CO_2-e
dNa_{XGL}	Total number of animals to be displaced to *XGL* areas; dimensionless

8.1.3 Estimation of $LK_{conv\text{-}crop}$ (Leakage due to conversion of land to crop land, based on area of conversion)

'Activity shifting' or 'activity displacement' may result in leakage immediately after the start of the project activity when activities are displaced to areas outside the project boundary. However, leakage due to conversion of land is not attributable to the AR CDM project activity if the conversion of land occurs 5 or more years after the displacement of the activity to areas outside the project boundary. The type and schedule of measures to be taken to prevent the conversion of land outside the project boundary should therefore be described in the AR-CDM-PDD and its implementation monitored.

Alternative methodologies are presented for analyses at the household or at the community level (the household analysis is only appropriate where continued ownership or occupation of land parcels can be shown). For the household level analysis, over the five-year period, 10 % of the randomly selected displaced households (or a minimum of randomly selected 30 households) will be tracked with respect to their land use. For the community level analysis, the land use of randomly selected 10 % of the communities (or a minimum of 10 communities) displaced or partially displaced by project activities will be tracked, with 10% of randomly selected households (or a minimum of 10 randomly selected households) in each community sampled to determine the area of unidentifiable conversion in the five years after the start of displacement from project area. The community level analysis allows for communities of differing sizes.

$$LK_{conv\text{-}crop} = CS_{AD} - CS_b \quad \textbf{(43)}$$

where:

$LK_{conv\text{-}crop}$	Leakage resulting from the conversion for cropland
CS_{AD}	Locally derived carbon stock (including all five eligible carbon pools); t CO_2-e ha-^{1}) of area of land on which activities shifted; t CO_2-e ha-1
CS_b	Carbon stock of baseline; t CO_2-e ha^{-1}

Case 1: $CS_{AD} < CS_b$

Leakage due to displacement for cropland can be set as zero if the carbon stock on the land to which crops are displaced is less than the carbon stock from which they originated under the baseline scenario.

$$L_{conv\text{-}crop} = 0, \text{ if } CS_{AD} < CS_b \quad \textbf{(44)}$$

Case 2: $CS_{AD} > CS_b$

However, if activities are displaced to land with higher stocks, then a leakage debit should be taken by the project. Carbon stock decreases through biomass losses will be calculated by multiplying the area of land conversion by the carbon stock. Land holdings are broken down into two types:

- Land holdings with areas of geographically identifiable land conversion outside the project boundary. The area of identifiable land converted by a sampled displaced household or community is multiplied by the mean carbon stock of the land strata type prior to conversion. If the previous land strata type is unknown, the strata with the highest carbon stock will be used;
- Land holdings with areas of geographically unidentifiable land conversion outside the project boundary. This may be due to migration of households to unknown locations or any other circumstance that causes the location of the households' converted land to be unknown. Where the land households convert is unidentifiable, leakage GHG emissions is conservatively assumed equal to the area of land from which the household was displaced multiplied by a conservative value for regional forest biomass stock.

(a) Household level

Step 1: Randomly select households to be sampled (10% of all households or a minimum of 30 households), e.g by selecting them systematically from a list of all households listed in alphabetic order.

Step 2: Measure area of cropland within project boundaries each sampled household will be displaced from.

Step 3: Interview sampled household to determine total area of cropland owned by each household that is planted ($TACP_h$), and the land cover class (CS_i) of the area (IAC_{hi}) and that each household intends to convert.

Step 4: Estimate the carbon stock in each land cover stratum using methods detailed in IPCC GPG-LULUCF chapter 4.3, including all pools.

Step 5: Determine the mean conservative forest biomass stock for the project region ($\overline{CS}$) for application to unidentified areas.

Step 6: Calculate the leakage using the following equations:

$$LK_{conv-crop} = \sum_{hh=1}^{Hh}\left(\sum_{i=1}^{I} IAC_{hi} \cdot CS_i\right) \cdot SF + \sum_{hh=1}^{Hh}\left(TACP_h - \sum_{i=1}^{I} IAC_{hi}\right) \cdot \overline{CS} \cdot SF \quad \textbf{(45)}$$

and:

$$SF = \frac{TNHH}{SHH} \quad \textbf{(46)}$$

where:

$LK_{conv-crop}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting); t CO_2-e
IAC_{hi}	Identifiable areas converted by household *hh* in stratum *i*; hectares
$TACP_h$	Total area of cropland planted that is owned by household *h*; hectares
hh	1,2,3….*Hh* households; dimensionless

i	1,2,3….I strata; dimensionless
CS_i	Locally derived carbon stock of identified lands (including all the five eligible carbon pools) of stratum i; t CO_2-e. ha^{-1}
$\overline{CS}$	Locally derived average carbon stock of unidentified lands (including all the five eligible carbon pools); t CO_2-e. ha^{-1}
SF	Sampling factor of household; dimensionless
$TNHH$	Total number of households using project lands in baseline; dimensionless
SHH	Sampled households, number of households sampled for $LK_{conv\text{-}crop}$; dimensionless

(b) <u>Community level</u>

For the community based estimate, one calculates the leakage per community using an equation similar to equation 45 and then one sums over the communities based on area.

Step 1: Record the number of communities occupying land inside the project boundary. Randomly select 10% of the communities (or a minimum of 10 communities) to be sampled.

Step 2: Measure total area of cropland within project boundaries from which pre-project activities in each sampled community will be displaced ($TACP_c$).

Step 3: Calculate the number of households within each selected community ($TNHH_c$).

Step 4: Randomly select 10% of households (or a minimum of 10 households) to be sampled within selected communities, e.g by selecting them systematically from a list of all households listed in alphabetic order.

Step 5: Interview community members to estimate the area of identifiable land that each sampled community will convert due to displacement of pre-project activities (IAC_{hc}).

Step 6: Classify the estimated area of identifiable land that may be converted within the community into a pre-conversion land cover stratum.

Step 7: Estimate the carbon stock (including all 5 carbon pools) in each land cover stratum using methods detailed in IPCC GPG-LULUCF chapter 4.3 (CS_i).

Step 8: Determine the mean conservative forest biomass stock for the project region ($\overline{CS}$) for application to unidentified areas;

Step 9: Calculate the leakage using the following equations:

$$LK_{conv-crop,c} = \sum_{hh=1}^{Hh_c}\left(\sum_{i=1}^{I} IAC_{hci} \cdot CS_i\right) \cdot SF_c + \sum_{hh=1}^{Hh_c}\left(TACP_c - \sum_{i=1}^{I} IAC_{hci}\right) \cdot \overline{CS} \cdot SF_c \quad \textbf{(47)}$$

$$SF_c = \frac{TNHH_c}{SHH_c} \quad \textbf{(48)}$$

$$LK_{conv-crop} = TACP \cdot \frac{\sum_{c=1}^{C} LK_{conv-crop,c}}{\sum_{c=1}^{C} TACP_c} \quad \textbf{(49)}$$

where:

$LK_{conv\text{-}crop}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting); t CO_2-e
$LK_{conv\text{-}crop,c}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting) in community *c*; t CO_2-e
TACP	Total area of land on which pre-project activities were displaced due to project activities; hectares
$TACP_c$	Total area of land on which pre-project activities were displaced due to project activities in community *c*; hectares
IAC_{hci}	Identifiable areas converted of stratum *i* by household *hh* in community *c*; hectares
CS_i	Locally derived carbon stock (including all the five eligible carbon pools) of stratum *i*; t CO_2-e ha^{-1}
$\overline{CS}$	Locally derived average carbon stock of unidentified lands (including all the five eligible carbon pools); t CO_2-e ha^{-1}
$TNHH_c$	Total number of households using project lands in baseline in community *c*; dimensionless
SHH_c	Sampled households in community *c*, number of households sampled for leakage by activity shifting; dimensionless
SF_c	Sampling factor for community *c*; dimensionless
c	1,2,3…*C*, communities; dimensionless
i	1,2,3….*I,* strata; dimensionless
hh	1,2,3, Hh_c, households in community *c;* dimensionless

8.1.4 Estimation of $LK_{fuel\text{-}wood}$ (Leakage due to displacement of fuel-wood collection)

Depending on the specific project circumstance, all pre-project fuel-wood collection activities (including in-site charcoal production), or a fraction of them, may have to be displaced permanently, or temporarily, outside the project boundary. Where pre-project fuel-wood collection and/or charcoal production activities exist, it is necessary to estimate the pre-project consumption of fuel-wood in randomly selected different discrete parcels or (subareas) within the project area. This can be done by interviewing households or implementing a Participatory Rural Appraisal (PRA). Where several discrete parcels are present in the project area, sampling techniques can be used. Others sources of information, such as local studies on fuel-wood consumption and/or charcoal production may also be used. Average data from the 5 to 10 years time period preceding the starting date of the AR CDM project activity should be used whenever possible.

$$FG_{BL} = \frac{sFG_{BL}}{SFR_{PAfw}} \quad \textbf{(50)}$$

where:

FG_{BL}	Average pre-project annual volume of fuel-wood gathering in the project area; $m^3\ yr^{-1}$
sFG_{BL}	Sampled average pre-project annual volume of fuel-wood gathering in the project area; $m^3\ yr^{-1}$
SFR_{PAfw}	Fraction of total area or households in the project area sampled; dimensionless

Given the conditions under which this methodology is applicable (see Section I.3), particularly the applicability of baseline approach 22(a), the methodology assumes that the estimated historical or current fuel-wood consumption and/or charcoal production (FG_{BL}) will remain constant over the entire crediting period. Based on the planned afforestation or reforestation establishment schedule and the prescribed management, the periods of time from which fuel-wood collection and/or charcoal production should be excluded from the considered sample discrete areas as well as the amounts of fuel-wood produced in the different stands through thinning, coppicing and harvesting can be specified. This planning should be used to estimate the amount of fuel-wood and/or charcoal that may have to be obtained each year from sources outside the project boundary.

$$FG_{outside,t} = FG_{BL} - FG_{AR,t} \tag{51}$$

where:

$FG_{outside,t}$	Volume of fuel-wood gathering displaced outside the project area at year t; $m^3\ yr^{-1}$
FG_{BL}	Average pre-project annual volume of fuel-wood gathering in the project area; $m^3\ yr$-^{1}
$FG_{AR,t}$	Volume of fuel-wood gathering allowed/planned in the project area under the proposed AR CDM project activity; $m^3\ yr^{-1}$

Leakage due to displacement of fuel-wood collection can be set as zero ($LK_{fuel\text{-}wood} = 0$) under the following circumstances:

- $FG_{BL} < FG_{AR,t}$;
- $LK_{fuel\text{-}wood} < 2\%$ of actual net GHG removals by sinks (See EB 22, Annex 15).

In all other cases, leakage due to displacement of fuel-wood collection shall be estimated as follow (IPCC GPG-LULUCF - Equation 3.2.8):

$$LK_{fuel-wood} = \sum_{t=1}^{t^*} FG_t \cdot D \cdot BEF_2 \cdot CF \cdot \frac{44}{12} \tag{52}$$

$$FG_t = FG_{outside,t} - FG_{NGL,\ t} \tag{53}$$

where:

$LK_{fuel\text{-}wood}$	Leakage due to displacement of fuel-wood collection up to year t^*; t CO_2-e
FG_t	Volume of fuel-wood gathering displaced in unidentified areas; $m^3\ yr^{-1}$
$FG_{outside,t}$	Volume of fuel-wood gathering displaced outside the project area at year t; $m^3\ yr^{-1}$
$FG_{NGL,t}$	Volume of fuel-wood gathering in *NGL* areas and supplied to pre-project fuel-wood collectors and/or charcoal producers; $m^3\ yr^{-1}$
D	Average basic wood density; t d.m. m^{-3} (See IPCC GPG-LULUCF, Table 3A.1.9)

BEF_2	Biomass expansion factor for converting volumes of extracted round wood to total above-ground biomass (including bark); dimensionless Table 3A.1.10
CF	Carbon fraction of dry matter (default = 0.5); t C (t d.m.)$^{-1}$

9. *Ex ante* net anthropogenic GHG removal by sinks

The net anthropogenic GHG removals by sinks is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage, therefore, the following general formula can be used to calculate the net anthropogenic GHG removals by sinks of an A/R CDM project activity (C_{AR-CDM}), in t CO_2-e:

$$C_{AR-CDM} = C_{ACTUAL} - C_{BSL} - LK \quad \textbf{(54)}$$

where:

C_{AR-CDM}	Net anthropogenic greenhouse gas removals by sinks; t CO_2-e
C_{ACTUAL}	Actual net greenhouse gas removals by sinks (equation 13); t CO_2-e
C_{BSL}	Baseline net greenhouse gas removals by sinks (equation 1 or 2); t CO_2-e
LK	Leakage (27); t CO_2-e

Note: In this methodology equation 55 is used to estimate net anthropogenic GHG removals by sinks for the period of time elapsed between project start (*t=1*) and the year *t=t*, t** being the year for which actual net greenhouse gas removals by sinks are estimated. This is done because project emissions and leakage are permanent, which requires to calculate their cumulative values since the starting date of the A/R CDM project activity.

Calculation of tCERs and lCERs

To estimate the amount of CERs that can be issued at time $t^* = t_2$ (the date of verification) for the monitoring period $T = t_2 - t_1$, this methodology uses the EB approved equations,[20] which produce the same estimates as the following:

$$tCERs = C_{AR-CDM,t2} \quad \textbf{(55)}$$

$$lCERs = C_{AR-CDM,t2} - C_{AR-CDM,t1} \quad \textbf{(56)}$$

where:

tCERs	Number of units of temporary Certified Emission Reductions
lCERs	Number of units of long-term Certified Emission Reductions
$C_{AR-CDM,t2}$	Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_2$; t CO_2-e
$C_{AR-CDM,t1}$	Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_1$; t CO_2-e

10. Uncertainties and conservative approach:

To help reduce uncertainties in the accounting of emissions and removals**,** this methodology uses whenever possible the proven methods from the GPG-LULUCF, GPG-2000, and the IPCC's Revised 2006 Guidelines. As well, tools and guidance from the CDM Executive Board on conservative estimation of emissions and removals are also used. Despite this, potential uncertainties still arise

[20] See EB 22, Annex 15 <http://cdm.unfccc.int/EB/Meetings/022/eb22_repan15.pdf>.

from the choice of parameters to be used. Uncertainties arising from, for example, biomass expansion factors (*BEFs*) or wood density, would result in uncertainties in the estimation of both baseline net GHG removals by sinks and the actual net GHG removals by sinks - especially when global default values are used.

It is recommended that PPs identify key parameters that would significantly influence the accuracy of estimates. Local values that are specific to the project circumstances should then be obtained for these key parameters, whenever possible. These values should be based on:

- Data from well-referenced peer-reviewed literature or other well-established published sources;[21] or
- National inventory data or default data from IPCC literature that has, whenever possible and necessary, been checked for consistency against available local data specific to the project circumstances; or
- In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value should be briefly noted in the CDM-AR-PDD. For any data provided by experts, the CDM-AR-PDD shall also record the experts name, affiliation, and principal qualification as an expert (e.g., that they are a member of a country's national forest inventory technical advisory group) as well as a 1-page summary CV for each expert consulted, included in an annex.

In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of default data, PPs should select values that will lead to an accurate estimation of net GHG removals by sinks, taking into account uncertainties. If uncertainty is significant, PPs should choose data such that it tends to under-estimate, rather than over-estimate, net GHG removals by sinks.

[21] Typically, citations for sources of data used should include: the report or paper title, publisher, page numbers, publication date etc (or a detailed web address). If web-based reports are cited, hardcopies should be included as Annexes in the CDM-AR-PDD if there is any likelihood such reports may not be permanently available.

11. Data needed for *ex ante* estimations

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
Historical land use/cover data	Determining baseline approach, Demonstrating eligibility of land	Earliest possible up to now	Local	Publications, government, interview
Land use/cover map	Demonstrating eligibility of land, stratifying land area	Before 1990 and most recent date	Regional, local	Forestry inventory
Satellite image	Same as above cell	1989/1990 and most recent date	Local	e.g. Landsat
Landform map	Stratifying land area	most recent date	1:10000	Local government
Soil map	Stratifying land area	most recent date	1:10000	Local government and institutional agencies
National and sectoral policies	Additionality consideration	Before 11 Nov. 2001	National and sectoral	Local government
UNFCCC, EB and AR-WG decisions - reports		1997 up to now	International	UNFCCC website
IRR, NPV cost benefit ratio, or unit cost of service	Indicators of investment analysis	Most recent date	Local	Calculation (if any, depends on the way of additionality analysis)
Investment costs	Including land purchase or rental, machinery, equipments, buildings, fences, site and soil preparation, seedling, planting, weeding, pesticides, fertilization, supervision, training, technical consultation, etc. that occur in the establishment period	Most recent date, taking into account market risk	Local	Local statistics, published data and/or survey (if any, depends on the way of additionality analysis)
Operations and maintenance costs	Including costs of thinning, pruning, harvesting, replanting, fuel, transportation, repairs, fire and disease control, patrolling, administration, etc.	Most recent date, taking into account market risk	Local	Local statistics, published data and/or survey (if any, depends on the way of additionality analysis)
Transaction costs	Including costs of project preparation, validation, registration, monitoring, etc.	Most recent date	National and international	DOE
Revenues	Those from timber, fuel-wood, non-wood products, with and without CER revenues, etc.	Most recent date, taking into account market risk	National and local	Local statistics, published data and/or survey (if any, depends on the way of additionality analysis)
12/44	Ration of molecular weights of carbon and CO_2; dimensionless		Global default	IPCC
16/12	Ration of molecular weights of CH_4 and carbon; dimensionless		Global default	IPCC
30	Average number of days in month; dimensionless			
44/12	Ratio of molecular weights of CO_2 and carbon; dimensionless		Global default	IPCC
44/28	Ratio of molecular weights of N_2O and nitrogen; dimensionless		Global default	IPCC
an	Animal type index (*An* = total number of animal types; dimensionless		Project	Estimated *ex ante*, monitored *ex post*

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
A	Total project area; ha	Most updated	Project	Estimated *ex ante*, monitored *ex post*
A_{B,ikt_sb}	Area of slash and burn in stratum *i*, stand model *k*, time t; ha		Project	Estimated *ex ante*, monitored *ex post*
$Adist_{ikt}$	Forest areas affected by disturbances in stratum *i,* stand model *k*, time *t*; ha yr^{-1}	Most updated	Stratum and species	Estimated *ex ante*, monitored *ex post*
$Adist_{ikT}$	Average annual area affected by disturbances for stratum *i,* stand model *k*, during the period *T*; ha yr^{-1}	Most updated	Stratum and species	Estimated *ex ante*, monitored *ex post*
a_{gpl}	Number of months per annum during which animals from the livestock group *g* are present at parcel *p*; dimensionless	Most updated	Project	Estimated *ex ante*, monitored *ex post*
A_{ikt}	Area of stratum *i,* stand model *k*, at time *t*; hectare (ha)	Most updated	Stratum and species	Estimated *ex ante*, monitored *ex post*
A_{ikt_sb}	Area of slash and burn for stratum *i*, stand model *k*, time *t*; ha	Most updated	Stratum and species	Estimated *ex ante*, monitored *ex post*
A_{ikT}	Average annual area for stratum *i,* stand model *k*, during the period *T*; ha yr^{-1}	Most updated	Stratum and species	Estimated *ex ante*, monitored *ex post*
aLK_{NGL}	Average leakage due to conversion of non-grassland to grassland per displaced animal in *NGL* areas; t CO_2-e. $animal^{-1}$	Most updated	Project	Calculated
aLK_{XGL}	Average leakage due to conversion of non-grassland to grassland per displaced animal in *XGL* areas; t CO_2-e. $animal^{-1}$	Most updated	Project	Calculated
$BEF_{1,j}$	Biomass expansion factor for conversion of annual net increment (including bark) in merchantable volume to total above-ground biomass increment for species *j;* dimensionless		Global default to local	GPG-LULUCF, national GHG inven-tory, local survey
BEF_2	Biomass expansion factor for converting volumes of extracted round wood to total above-ground biomass (including bark); dimensionless Table 3A.1.10		Global default to local	GPG-LULUCF, national GHG inventory, local survey
$BEF_{2,ijt}$	Biomass expansion factor for converting merchantable volumes of extracted round wood to total above-ground biomass (including bark) for stratum *i,* species *j*, time *t*; dimensionless		Global default to local	GPG-LULUCF, national GHG inventory, local survey
B_{ikt}	Average above-ground biomass stock before burning for stratum *i*, stand model *k*, time *t*; t d.m. ha^{-1}		Global default to local	GPG-LULUCF, national GHG inven-ory, local survey
$B_{pre,ikt}$	Average pre-existing stock on land to be planted before the start of a proposed A/R CDM project activity for baseline stratum *i*, stand model k, time t; t d.m. ha^{-1}	Most updated	Global default to local	GPG-LULUCF, national GHG inventory, local survey
$B_{w,ijt}$	Average above-ground biomass stock for stratum *i*, species *j*, time *t*; t d.m. ha^{-1}	Most updated	Local	National GHG inventory, local survey
c	Community index (C=total number of communities); dimensionless		Project	Estimated *ex ante*, monitored *ex post*
$C_{AB,ijt}$	Carbon stock in above-ground biomass for stratum *i,* species *j*, at time *t;* t C		Local and species specific	Calculated

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
$C_{NGLac\ t}$	Mean carbon stock including above and below-ground biomass of the NGL area converted to grassland at time *t*; CO_2-e.		Regional, local default	Estimated *ex ante*
$C_{XGLac\ t}$	Mean carbon stock including above and below-ground biomass of the XGL area converted to grassland at time *t*; CO_2-e.		Regional, local default	Estimated *ex ante*
C_{ACTUAL}	Actual net greenhouse gas removals by sinks; t CO_2-e.		Project specific	Calculated
$C_{AR\text{-}CDM}$	Net anthropogenic greenhouse gas removals by sinks; t CO_2-e.		Project specific	Calculated
$C_{AR\text{-}CDM,t1}$	Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_1$; t CO_2-e.		Project specific	Calculated
$C_{AR\text{-}CDM,t2}$	Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_2$; t CO_2-e.		Project specific	Calculated
$C_{BB,ijt}$	Carbon stock in below-ground biomass for stratum *i,* species *j*, at time *t;* t C		Local and species specific	Calculated
C_{BSL}	Baseline net greenhouse gas removals by sinks; t CO_2-e.		Project specific	Calculated
CE	Average biomass combustion efficiency; dimensionless		Global and national default	IPCC GPG-2000, national GHG inventory
CF_j	Carbon fraction for species *j*; t C (t d.m.)$^{-1}$		Global default to local	GPG-LULUCF, national GHG inventory
CF_{pre}	Carbon fraction of dry biomass in pre-existing vegetation, t C (t d.m.)$^{-1}$		Global default to local	GPG-LULUCF, national GHG inventory
C_{ikt}	Total carbon stock in living biomass for stratum *i,* stand model *k*, calculated at time *t*; t C		Stratum	Calculated
CS_i	Locally derived carbon stock (including all five eligible carbon pools) of stratum *i*; t CO_2.e. ha^{-1}	Most updated	Project	Calculated
$\overline{CS}$	Locally derived average carbon stock of unidentified lands (including all the five eligible carbon pools); t CO_2-e. ha^{-1}	Most updated	Project	Calculated
$C_{TOTAL,ikt}$	Average annual increment rate in total carbon stock in stratum *i,* stand model *k*, time *t*; t of CO_2 ha^{-1}.yr^{-1}		Stratum	Calculated
D	Average basic wood density; t d.m. m^{-3} (See IPCC GPG-LULUCF, Table 3A.1.9)		Global default to local	GPG-LULUCF, national GHG inventory
DBH	Tree diameter at breast height; cm		Project specific	Measured
DBI_j	Daily biomass intake by animal type *j*; kg d.m. head^{-1} day^{-1}		Global default to local	Estimated *ex ante*
D_j	Basic wood density for species *j*; t d.m. m^{-3} (See IPCC GPG-LULUCF, Table 3A.1.9)		Global default to local	GPG-LULUCF, national GHG inventory, local survey
dNa_{EGL}	Number of animals that can be displaced in *EGL* areas; dimensionless	Most updated	Project	Estimated *ex ante*, measured *ex post*

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
dNa_{NGL}	Number of animals that can be displaced in *NGL* areas; dimensionless	Most updated	Project	Estimated *ex ante*, measured *ex post*
dNa_{XGL}	Number of animals to be displaced in *XGL* areas; dimensionless	Most updated	Project	Estimated *ex ante*, measured *ex post*
$E_{acBiomassBurnt}$	Total non-CO_2 emissions from biomass burning in land converted to grazing land at time *t* (calculated from 100% of the above-ground biomass); t CO_2-e.	Most updated	Project	Calculated
$E_{BiomassBurn}$	Total increase in non-CO_2 emission as a result of biomass burning within the project boundary; t CO_2-e.	Most updated	Project	Calculated
$E_{BiomassBurn, CH4}$	CH_4 emission from biomass burning in slash and burn; t CO_2-e.	Most updated	Project	Calculated
$E_{BiomassBurn, N2O}$	N_2O emission from biomass burning in slash and burn; t CO_2-e.	Most updated	Project	Calculated
$E_{BiomassBurn,CO2}$	CO_2 emission from biomass burning in slash and burn; t CO_2-e.	Most updated	Project	Calculated
$E_{biomassloss}$	Decrease in the carbon stock in the living biomass carbon pools of non-tree vegetation in the year of site preparation	Most updated	Project	Calculated
EGL	Total existing grazing land area outside the project boundary that is under the control of the animal owners (or the project participants) and that will receive part of the displaced animal populations, up to time *t*;* ha		Project	Estimated *ex ante*
Ei	Emission/removal estimate for source/sink *i*			
ER_{CH4}	Emission ratio for CH_4 (IPCC default value = 0.012)		Global default	IPCC default value = 0.012
ER_{N2O}	Emission ratio for N_2O (IPCC default value = 0.007)		Global default	IPCC default value = 0.007
$FG_{AR,t}$	Volume of fuel-wood gathering allowed/planned in the project area under the proposed AR-CDM project activity; $m^3\ yr^{-1}$		Project	Estimated *ex ante*, measured *ex post*
FG_{BL}	Average pre-project annual volume of fuel-wood gathering in the project area; $m^3\ yr^{-1}$		Project	Estimated *ex ante*
FG_{ijt}	Annual volume of fuel wood harvesting for stratum *i,* species *j*, time *t*; $m^3\ ha^{-1}\ yr^{-1}$		Stratum	Estimated *ex ante*, monitored *ex post*
FG_{ijT}	Average annual volume of fuel wood harvested for stratum *i,* species *j*, during the period *T*; $m^3\ ha^{-1}\ yr^{-1}$		Stratum	Estimated *ex ante*, monitored *ex post*
$FG_{NGL,t}$	Volume of fuel-wood gathering in *NGL* areas and supplied to pre-project fuel-wood collectors and/or charcoal producers; $m^3\ yr^{-1}$		Project	Estimated *ex ante* and *ex post*
$FG_{outside,t}$	Volume of fuel-wood gathering displaced outside the project area at year *t*; $m^3\ yr^{-1}$		Project	Estimated *ex ante* and *ex post*
FG_t	Volume of fuel-wood gathering displaced in unidentified areas; $m^3\ yr^{-1}$		Project	Estimated *ex ante* and *ex post*
$f_i(DBH_t,H_t)$	An allometric equation linking above-ground biomass of living trees (d.m ha^{-1}) to mean diameter at breast height (DBH) and possibly mean tree height (H) for species *j*; dimensionless		National, local, species specific	Forestry inventory, published data, local survey

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
GHG_E	Sum of the increases in GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity; t CO_2-e.		Project specific	Calculated
GLA	Total grazing land area outside the project boundary needed to feed the displaced animal populations; ha		Project	Estimated *ex ante*
$G_{TOTAL,ijt}$	Annual average increment rate in total biomass in units of dry matter for stratum *i*, species *j*, time *t*; t d.m ha^{-1} yr^{-1}	Most recent	Global default to local	GPG-LULUCF, national and local forestry inventory
$G_{w,ijt}$	Average annual above-ground biomass increment for stratum *i*, species *j*, time *t*; t d.m ha^{-1} yr^{-1}		Global default to local	GPG-LULUCF, national GHG inventory
GWP_{CH4}	Global Warming Potential for CH_4		Global	IPCC default = 21
GWP_{N2O}	Global Warming Potential for N_2O		Global default	IPCC default = 310
hh	Household index (*Hh* = total number of households); dimensionless		Project	Estimated *ex ante*, monitored *ex post*
HH_c	total number of households in community *c*; dimensionless		Project	Estimated *ex ante*, monitored *ex post*
H	Tree height; m		Project	Estimated to measured *ex ante*, measured *ex post*
H_{ijt}	Annually extracted merchantable volume for stratum *i*, species *j*, time *t*; m^3 ha^{-1} yr^{-1}		Local/stand	Estimated *ex ante*, monitored *ex post*
H_{ijT}	Average annually harvested merchantable volume for stratum *i*, species *j*, during the period *T*; m^3 ha^{-1} yr^{-1}		Local/stand	Estimated *ex ante*, monitored *ex post*
i	Stratum index for both baseline strata and the strata of the project scenario		Project	Estimated *ex ante*, monitored *ex post*
IAC_{hi}	Identifiable areas converted in stratum *i* by household *hh*; hectares	Most updated	Project	Calculated
IAC_{hic}	Identifiable Areas Converted in stratum *i* by household *hh* in community *c*; hectares	Most updated	Project	Calculated
$I_{v,ijt}$	Average annual increment in merchantable volume for stratum *i*, species *j*, time *t*; m^3 ha^{-1} yr^{-1}		Local/stand	Estimated *ex ante*
$I_{v,ijT}$	Average annual net increment in merchantable volume for stratum *i*, species *j* during the period *T*; m^3 ha^{-1} yr^{-1}		Local/stand	Estimated *ex ante*
j	Species representing a specific stand model (*J* = total species)		Project	Estimated *ex ante*
k	Stand model consisting of one or several species (*K* = total stand models)			
lCERs	Number of units of long-term Certified Emission Reductions		Project	Calculated
$L_{fw,ijt}$	Annual carbon loss due to fuel wood gathering for stratum *i*, species *j*, time *t*; CO_2-e. yr^{-1}		Local/stand	Estimated *ex ante*, monitored *ex post*
$L_{hr,ijt}$	Annual carbon loss due to commercial harvesting for stratum *i*, species *j*, time *t*; t CO_2-e. yr^{-1}		Local/stand	Estimated *ex ante*, monitored *ex post*
LK	Total project leakage ; t CO_2-e.		Project	Calculated

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
$LK_{fuel\text{-}wood}$	Leakage due to the displacement of fuel-wood collection; t CO_2-e.		Project	Calculated
$LK_{ActivityDisplacement}$	Leakage due to activity displacement; t CO_2-e.		Project	Calculated
$LK_{conversion}$	Leakage due to conversion of land for grazing or cropland; t CO_2-e.		Project	Calculated
$LK_{conv\text{-}graz}$	Leakage resulting from conversion of land for grazing; t CO_2-e.		Project	Calculated
$LK_{conv\text{-}crop}$	Leakage resulting from conversion of land for cropland; t CO_2-e.		Project	Calculated
$LK_{conv\text{-}crop,c}$	Leakage resulting from conversion of land for cropland in community *c*; t CO_2-e.		Project	Calculated
LK_{NGL}	Leakage due to conversion of non-grassland to grassland in *NGL* areas under the control of the animal owners; t CO_2-e.		Project	Calculated
LK_{XGL}	Leakage due to conversion of non-grassland to grassland in unidentified *XGL* areas; t CO_2-e.		Project	Calculated
$L_{ot,ijt}$	Annual natural losses (mortality) of carbon for stratum *i*, species *j*, time *t*; CO_2-e. yr^{-1}		Local/stand	Calculated
Mf_{ijT}	Mortality factor = *percentage* of V_{ijt1} died during the period *T*; dimensionless		Local/stand	Estimated
m_{BL}	Total baseline strata			
m_{PS}	Total strata in project scenario			
Na	Total number of animals from the different livestock groups that are grazing in the project area (or in the sampled discrete areas); dimensionless		Project	Estimated-measured
$Na_{AR,t}$	Number of animals allowed in the project area under the proposed AR-CDM project activity at year *t*; dimensionless		Project	Estimated *ex ante*, monitored *ex post*
Na_{BL}	Average pre-project number of animals from the different livestock groups that are grazing in the project area; dimensionless		Project	Estimated *ex ante*
$Na_{EGL,t=1}$	Average number of animals present in the *EGL* areas selected for monitoring at project start; dimensionless		Project	Estimated *ex ante*, monitored *ex post*
$Na_{NGL,t=1}$	Average number of animals present in the *NGL* areas selected for monitoring at project start; dimensionless		Project	Estimated *ex ante*, monitored *ex post*
$Na_{outside,t}$	Number of animals displaced outside the project area at year *t*; dimensionless		Project	Estimated *ex ante*, monitored *ex post*
Na_s	Number of animals from the different livestock groups that the animal owners intend to sell as a consequence of the project implementation; dimensionless		Project	Estimated *ex ante*, monitored *ex post*
N/C ratio	Nitrogen-carbon ratio; dimensionless		Global	IPCC
NGL	Total new grazing land area outside the project boundary to be converted to grazing land that is under the control of the animal owners (or the project participants) and that will receive another part of the displaced animal populations, up to time *t*;* ha		Project	Estimated *ex ante*
ngl_t	Total area converted to grassland at time *t*; ha		Project	Estimated *ex ante*

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
n_{pgt}	Number of individual animals from the livestock group *g* at parcel *p* at time *t*; dimensionless		Project	Estimated *ex ante*
nTR_{ijt}	Number of trees in stratum *i*, species *j*, at time *t*; dimensionless ha^{-1}		Project	Estimated *ex ante*, monitored *ex post*
p	Parcel index (*P* = total number of parcels); dimensionless		Index	
PBB_{ikt}	Average proportion of biomass burnt for stratum *i*, stand model *k*, time *t*; dimensionless		Global and national default	IPCC GPG-2000, national GHG inventory
R_j	Root-shoot ratio appropriate to increments for species *j*; dimensionless		Global default to local	GPG-LULUCF, national GHG inventory, local survey
SF	Sampling factor; dimensionless		Project	Calculated *ex ante*
SF_c	Sampling factor of community *c*; dimensionless		Project	Calculated *ex ante*
sFG_{BL}	Sampled average pre-project annual volume of fuel-wood gathering in the project area; $m^3\ yr^{-1}$		Project	Estimated *ex ante* and *ex post*
SFR_{PAfw}	Fraction of total area or households in the project area sampled for fuel-wood; dimensionless		Project	Defined *ex ante*
SFR_{PAga}	Fraction of total area or households in the project area sampled for grazing animals; dimensionless		Project	Defined *ex ante*
SFR_{EGL}	Fraction of total *EGL* areas sampled; dimensionless		Project	Defined *ex ante*
SFR_{NGL}	Fraction of total *NGL* areas sampled; dimensionless		Project	Defined *ex ante*
SHH	Sampled households, number of households sampled for $LK_{conv\text{-}crop}$; dimensionless		Project	Defined *ex ante*
SHH_c	Sampled households in community *c*, number of households sampled for $LK_{conv\text{-}crop}$; dimensionless		Project	Defined *ex ante*
sNa_{BL}	Sampled pre-project number of animals from the different livestock groups that are grazing in the project area; dimensionless		Project	Estimated *ex ante*
t	1, 2, 3, …*t** years elapsed since the start of the A/R CDM project activity		Project	Estimated *ex ante*, monitored *ex post*
T	Number of years between times t_2 and t_1 $(T = t_2 - t_1)$		Project	Estimated *ex ante*, monitored *ex post*
*t**	Number of years elapsed since the start of the A/R project activity; yr			
TACP	Total Area of Cropland Planted by the project; hectares	Most updated	Project	Calculated
$TACP_c$	Total area of cropland planted that is owned by community *c*; hectares	Most updated	Project	Calculated
$TACP_h$	Total area of cropland planted that is owned by household *hh*; hectares	Most updated	Project	Calculated
tCERs	Number of units of temporary Certified Emission Reductions		Project	Calculated

Data/Parameters	Descriptions	Vintage	Data sources and geographical scale	
t_{cp}	Year at which the first crediting period ends; yr			
TNHH	Total number of households using project lands in baseline; dimensionless	Most updated	Project	Calculated
$TNHH_c$	Total number of households using project lands in baseline in community *c*; dimensionless	Most updated	Project	Calculated
V_{ijt}	Average merchantable volume of stratum *i*, species *j*, at time *t;* m^3 ha^{-1}		Local and species specific	Forestry inventory, yield table, local survey
V_{ijt1}	Average merchantable volume of stratum *i*, species *j*, at time $t = t_1$; m^3 ha^{-1}		Local and species specific	Forestry inventory, yield table, local survey
V_{ijt2}	Average merchantable volume of stratum *i*, species *j*, at time $t = t_2$; m^3 ha^{-1}		Local and species specific	Forestry inventory, yield table, local survey
WB_{ht}	Fraction of total above-ground biomass harvested as timber and as fuel-wood at time *t* (not burned); dimensionless		Defined *ex ante*	Estimated *ex ante* and *ex post*
XGL	Total unidentifiable grazing land area outside the project boundary that will receive the remaining part of displaced animal populations, e.g. when the pre-project animal owners decide to sell the animals, up to time *t**; ha		Project	Estimated *ex ante* and *ex post*
xgl_t	Total unidentifiable area converted to grassland at time *t*; ha		Project	Estimated *ex ante*, monitored *ex post*
ΔC_{av}	Average annual biomass consumed by one average animal; t d.m.yr^{-1}		Project	Estimated *ex ante*
$\Delta C_{G,ikt}$	Annual increase in carbon *stock* due to biomass growth for stratum *i,* stand model *k,* time *t*; t CO_2-e. yr^{-1}		Project	Estimated *ex ante*, monitored *ex post*
ΔC_{ikt}	Annual carbon stock change in living biomass for stratum *i,* stand model *k*, time *t;* t CO_2-e. yr^{-1}.		Project	Estimated *ex ante*, monitored *ex post*
$\Delta C_{L,ikt}$	Annual decrease in carbon *stock* due to biomass loss for stratum *i,* stand model *k*, time *t;* t CO_2-e. yr^{-1}		Project	Estimated *ex ante*
$\Delta C_{L\ PA,t}$	Annual animal biomass consumption over the project area to be planted at time *t*; t d.m.yr^{-1}		Project	Estimated *ex ante*
$\Delta C_{Lcurrent}$	Current annual biomass that the grazing areas can produce for animal feeding; t d.m.yr^{-1}		Project	Estimated *ex ante*
ΔC_{Lmax}	Maximum annual biomass that the grazing areas can produce for animal feeding; t d.m.yr^{-1}		Project	Estimated *ex ante*

12. Other information

None.

Section III: Monitoring methodology description

The proposed new methodology proposes methods for monitoring the following elements:

- The proposed A/R CDM project activity including the project boundary, forest establishment, and forest management activities;
- Actual net GHG removals by sinks including changes in carbon stock in above-ground biomass and below-ground biomass, increase in GHG emissions within the project boundary due to site preparation, transportation, thinning and logging and nitrogen fertilization;
- Leakage due to displacement of agricultural crops, grazing and fuel-wood collection activities;
- A Quality Assurance/Quality Control plan, including field measurements, data collection verification, data entry and archiving, as an integral part of the monitoring plan of the proposed A/R CDM project activity, to ensure the integrity of data collected.

The baseline net GHG removals by sinks are assumed to be constant due to acceptance of the baseline approach 22 (a) in the related baseline methodology. The proposed monitoring methodology stratifies the project area based on local climate, existing vegetation, site class and tree species to be planted with the aid of land use/cover maps, satellite images, soil map, GPS and/or field survey. The proposed methodology uses permanent sample plots to monitor carbon stock changes in living biomass pools. The methodology first determines the number of plots needed in each stratum/sub-stratum to reach the targeted precision level of ±10% of the mean at the 90% confidence level. GPS located plots ensure the measuring and monitoring consistently over time.

1. Monitoring project boundary and project implementation:

Monitoring of project implementation includes:

- Monitoring of the project boundary;
- Monitoring of forest establishment;
- Monitoring of forest management.

The corresponding methodology procedures are outlined below.

1.1 Monitoring of the boundary of the proposed A/R CDM project activity

This is meant to demonstrate that the actual area afforested or reforested conforms with the afforestation or reforestation area outlined in the PDD. The following activities are foreseen:

- Field surveys concerning the project boundary within which the A/R activity has occurred, site by site;
- Measuring geographical positions (latitude and longitude of each corner polygon sites) using GPS;
- Checking whether the afforested/reforested areas are consistent with the eligible areas as defined in the CDM-AR-PDD;

- If afforestation/reforestation activities fall outside of the project boundary as defined in the CDM-AR-PDD, these lands shall not be accounted as a part of the A/R CDM project activity;
- Input the measured geographical positions into the GIS system and calculate the implemented area of each stratum and stand;
- The development of the tree cover shall be monitored periodically all through the crediting period, including through remote sensing as applicable. If tree cover is affected by natural hazards (forest fires, plagues, etc.) or human interventions (harvesting, deforestation) beyond average regional damage levels, location; area of the deforested land and carbon losses shall be identified. These areas shall be treated as separate strata. Similarly, if the planting on certain lands within the project boundary fails these lands will be documented;
- Monitoring of forest establishment.

To ensure that the planting quality conforms to the practice described in AR-CDM-PDD and is well implemented, the following monitoring activities shall be conducted in the first three years after planting:

- Confirm that site and soil preparations are implemented based on practice documented in PDD. If pre-vegetation is removed, e.g., slash and burn of pre-existing vegetation,[22] emissions associated shall be accounted for (described in section below);
- Survey and check that species and planting for each stratum are in line with the PDD;
- Document and justify any deviation from the planned forest establishment.

1.2 Monitoring of forest management

Forest management practices are important drivers of the GHG balance of the project, and thus must be monitored. Practices to be monitored include:

- Cleaning and site preparation measures: date, location, area, biomass removed and other measures undertaken;
- Planting: date, location, area, tree species (establishment of the stand models);
- Thinning: date, location, area, tree species, thinning intensity, volumes or biomass removed;
- Harvesting: date, location, area, tree species, volumes or biomass removed;
- Coppicing: date, location, area, tree species, volumes or biomass removed;
- Fuel wood collection: date, location, area, tree species, volumes or biomass removed;

[22] In accordance with guidance contained in paragraph 35 of EB 42 meeting report, GHG emissions due to removal (loss) of herbaceous vegetation as a component of non-tree biomass are neglected in this methodology. Hence, all references to GHG emission from removal of non-tree vegetation do not include GHG emissions from removal of herbaceous vegetation..

- Checking and confirming that harvested lands are re-planted, re-sowed or coppiced as planned and/or as required by forest law;
- Checking and ensuring that good conditions exist for natural regeneration if harvested lands are allowed to regenerate naturally;
- Monitoring of disturbances: date, location, area (GPS coordinates and remote sensing, as applicable), tree species, type of disturbance, biomass lost, implemented corrective measures, change in the boundary of strata and stands.

2. Stratification and sampling for *ex post* calculations

The number and boundaries of the strata defined *ex ante* using the methodology procedure outlined in Section II.2 may change during the crediting period (*ex post*). For this reason, strata should be monitored periodically. If a change in the number and area of the project strata occurs, the sampling framework should be adjusted accordingly. The methodology procedures for monitoring strata and defining the sampling framework are outlined below.

2.1 Monitoring of strata

Stratification of the project area into relatively homogeneous units can either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit.

Project participants should present in the AR-CDM-PDD an *ex ante* stratification of the project area using the methods outlined in Section II.2 and build a geo-referenced spatial data base in a GIS platform for each parameter used for stratification of the project area under the baseline and the project scenario. This geo-referenced spatial database shall be updated periodically due to the following reasons:

- Unexpected disturbances occurring during the crediting period (e.g. due to fire, pests or disease outbreaks), affecting differently different parts of an originally homogeneous stratum or stand;
- Forest management (cleaning, planting, thinning, harvesting, coppicing, re-replanting) may be implemented at different intensities, dates and spatial locations than originally planned in the PDD;
- Eligible land areas as defined in the AR-CDM-PDD not yet under the control of the project participant at the start of the project activity have become under the control of the project participants (see Section II.1, point c);
- Two different strata may be similar enough to allow their merging into one stratum.

If one of the above occurs, *ex post* stratification may be required. The possible need for *ex post* stratification shall be evaluated at each monitoring event and changes in the strata should be reported to the DOE for verification.

Monitoring of strata and stand boundaries shall be done using a Geographical Information System (GIS), which allows for integrating data from different sources (including GPS coordinates and remote sensing data). The monitoring of strata and stand boundaries is critical for a transparent and verifiable monitoring of the variable A_{ikt} (area of stratum *i,* stand model *k*, at time *t*), which is of outmost importance for an accurate and precise calculation of net anthropogenic GHG removals by sinks.

2.2 Sampling framework

The sampling framework, including sample size, plot size, plot shape and plot location should be specified in the CDM-AR-PDD.

2.2.1 Definition of the sample size and allocation among strata

Permanent sampling plots will be used for sampling over time to measure and monitor changes in carbon stocks. Permanent sample plots are generally regarded as statistically efficient in estimating changes in forest carbon stocks because typically there is high covariance between observations at successive sampling events. However, it should be ensured that the plots are treated in the same way as other lands within the project boundary, e.g., during site and soil preparation, weeding, fertilization, irrigation, thinning, etc., and should not be destroyed over the monitoring interval. Ideally, staff involved in management activities should not be aware of the location of monitoring plots. Where local markers are used, these should not be visible.

The number of sample plots is estimated as dependent on accuracy and costs.

It is assumed that the following parameters are from pre-project estimates (e.g. results from a pilot-study) or literature data:

A	Total size of all strata (A), e.g. the total project area; ha
A_i	Size of each stratum (= $\sum_{t=1}^{tcr}\sum_{k}^{K_P} A_{ikt}$ where *tcr* is the end of the crediting period); ha
k	1, 2, 3, … K_P stand models in the project scenario
A_{ikt}	Area of stratum *i*, stand model *k*, time *t*; ha
AP	Sample plot size; ha
st_i	Standard deviation for each stratum *i*; dimensionless
C_i	Cost of establishment of a sample plot for each stratum *i;* e.g. US$
Q	Approximate average value of the estimated quantity *Q,* (e.g. wood volume); e.g. $m^3\ ha^{-1}$
DLP	Desired level of precision (e.g. 10%); dimensionless

Then:

$$N = \frac{A}{AP} \;\; ; \;\; N_i = \frac{A_i}{AP} \;\; ; \;\; E = Q \cdot DLP \qquad \textbf{(57)}$$

where:

N	Maximum possible number of sample plots in the project area
N_i	Maximum possible number of sample plots in stratum *i*
E	Allowable error

With the above information, the sample size (number of sample plots to be established and measured) can be estimated as follows:

$$n = \frac{\left[\sum_{i=1}^{m_{PS}} N_i \cdot st_i \cdot \sqrt{Ci}\right] \cdot \left[\sum_{i=1}^{m_{PS}} N_i \cdot st_i \cdot \frac{1}{\sqrt{C_i}}\right]}{\left(N \cdot \frac{E}{z_{\alpha/2}}\right)^2 + \sum_{i=1}^{m_{PS}} N_i \cdot (st_i)^2} \quad \textbf{(58)}$$

$$n_i = \frac{\sum_{i=1}^{m_{PS}} N_i \cdot st_i \cdot \sqrt{C_i}}{\left(N \cdot \frac{E}{z_{\alpha/2}}\right)^2 + \sum_{i=1}^{m_{SP}} N_i \cdot (st_i)^2} \cdot \frac{N_i \cdot st_i}{\sqrt{C_i}} \quad \textbf{(59)}$$

where:

n Sample size (total number of sample plots required) in the project area

n_i Sample size for stratum i

i 1, 2, 3, ... m_{SP} project scenario (*ex post*) strata

$z_{\alpha/2}$ Value of the statistic z (normal probability density function), for $\alpha = 0.1$ (implying a 90% confidence level)

When no information on costs is available or the costs may be assumed as constant for all strata, then:

$$n = \frac{\left[\sum_{i=1}^{m_{PS}} N_i \cdot st_i\right]^2}{\left(N \cdot \frac{E}{z_{\alpha/2}}\right)^2 + \sum_{i=1}^{m_{PS}} N_i \cdot (st_i)^2} \quad \textbf{(60)}$$

$$n_i = \frac{\sum_{h=1}^{m_{PS}} N_i \cdot st_i}{\left(N \cdot \frac{E}{z_{\alpha/2}}\right)^2 + \sum_{i=1}^{m_{PS}} N_i \cdot (st_i)^2} \cdot N_i \cdot st_i \quad \textbf{(61)}$$

It is possible to reasonably modify the sample size after the first monitoring event based on the actual variation of the carbon stocks determined from taking the n samples.

2.2.2 Sample plot size

The plot area *a* has major influence on the sampling intensity and time and resources spent in the field measurements. The area of a plot depends on the stand density. Therefore, increasing the plot area decreases the variability between two samples. According to Freese (1962),[23] the relationship between coefficient of variation and plot area can be denoted as follows:

$$CV_2^{\,2} = CV_1^{\,2} \cdot \sqrt{\frac{a_1}{a_2}} \tag{62}$$

where a_1 and a_2 represent different sample plot areas and their corresponding coefficient of variation (*CV*).

Thus, by increasing the sample plot area, variation among plots can be reduced permitting the use of small sample size at the same precision level. Usually, the size of plots is between 100 m^2 for dense stands and 1000 m^2 for open stands.

2.2.3 Plot location

To avoid subjective choice of plot locations (plot centers, plot reference points, movement of plot centers to more 'convenient' positions), the permanent sample plots shall be located systematically with a random start, which is considered good practice in IPCC GPG-LULUCF. This can be accomplished with the help of a GPS in the field. The geographical position (GPS coordinate), administrative location, stratum and stand, series number of each plots shall be recorded and archived.

Also, it is to be ensured that the sampling plots are as evenly distributed as possible. For example, if one stratum consists of three geographically separated sites, then it is proposed to:

- Divide the total stratum area by the number of plots, resulting in the average area represented by each plot;
- Divide the area of each site by this average area per plot, and assign the integer part of the result to this site. e.g., if the division results in 6.3 plots, then 6 plots are assigned to this site, and 0.3 plots are carried over to the next site, and so on.

2.2.4 Monitoring frequency

Monitoring interval depends on the variability in carbon stocks and the rate of carbon accumulation, i.e., the growth rate of trees as of living biomass. Although the verification and certification shall be carried out every five years after the first verification until the end of the crediting period (paragraph 32 of decision 19/CP.9), monitoring interval may be less than five years. However, to reduce the monitoring cost, the monitoring intervals shall coincide with verification time, i.e., five years of interval. Logically, one monitoring and verification event will take place close to the end of the first commitment period, e.g. in the second half of the year 2012.

Project participants shall determine the first monitoring time, taking into account:

- The growth rate of trees and the financial needs of the project activity: the later the date of the first verification, the higher will be the amount of net anthropogenic GHG removals by sinks but the lower the financial net present value of a CER;

[23] Freese, F. 1962. Elementary Forest Sampling. USDA Handbook 232. GPO Washington, DC. 91 pp.

- Harvesting events and rotation length: The time of monitoring and subsequent verification and certification shall not coincide with peaks in carbon stocks based on paragraph 12 of Appendix B in decision 19/CP.9.

2.2.5 Measuring and estimating carbon stock changes over time

The growth of individual trees on plots shall be measured at each monitoring event. Pre-existing (baseline) trees should conservatively and consistently with the baseline methodology not be measured and accounted for. Although non-tree vegetation such as herbaceous plants, grasses, and shrubs can occur, usually with biomass less than 10 percent, there is also non-tree vegetation on degraded lands and the baseline scenario has assumed the zero stock change for this non-tree biomass. Therefore, non-tree vegetation will not be measured and accounted. The omission of non-tree biomass makes the monitoring conservative. Even if the initial site preparation results in a removal of non-tree biomass, there is no risk to over-estimate the removals. The carbon stock changes in living biomass on each plot are then estimated through Biomass Expansion Factors (BEF) method or allometric equations method.

2.2.6 Monitoring GHG emissions by sources increased as results of the A/R CDM project activity

An A/R CDM project activity may increase GHG emissions, in particular CO_2, CH_4 and N_2O. The list below contains factors that may result in an increase of GHG emissions:[24]

- Emissions of greenhouse gases from biomass burning for site preparation (slash and burn activity).

Changes in GHG emissions caused by these practices can be estimated by monitoring activity data and selecting appropriate emission factors.

3. Calculation of *ex post* baseline net GHG removals by sinks, if required

The baseline carbon stock changes do not need to be monitored after the project is established, because the accepted baseline approach 22(a) assumes continuation of existing changes in carbon pools within the project boundary from the time of project validation.

However, if the project participants choose a renewable crediting period, relevant data necessary for determining the renewed baseline, including net greenhouse gas removals by sinks during the crediting period, shall be collected and archived to determine whether the baseline approach and baseline scenario are still valid or have to be updated. Reasons for a possible need for updating may include:

- National, local and sectoral policies that may influence land use in the absence of the proposed A/R CDM project activity;
- Technical progresses that may change the baseline approach and baseline scenario;
- Climate conditions and other environmental factors that may change to such a degree as to significantly change the successional and disturbance processes or species composition, resulting in, e.g., improved climate conditions and/or available seed source would make the natural regeneration possible that is not expected to occur for the current baseline scenario;
- Significant changes of political, social and economic situation, making baseline approach and the projection of baseline scenario unreasonable;

[24] Refer to Box 4.3.1 and Box 4.3.4 in IPCC GPG-LULUCF.

- Existing barriers that may be removed, for instance:
    - Removal of existing investment barriers: Local farmers (communities) can afford the high establishment investment in the early stage or have chance to get commercial loans from banks for the reforestation activity;
    - Removal of existing technological barriers: Local farmers (communities) get knowledge and skills for producing high quality seedling, successful tree planting, controlling forest fire, pest and disease, and etc.;
    - Removal of existing institutional barriers (e.g., well-organized institutional instruments to integrate separate households and address technological and financial barriers).
- Market that may change the alternative land use, e.g., significant price rising of wood and non-woody products would make the degraded land economically attractive in the absence of the proposed A/R CDM project activity;
- Check that the baseline net GHG removals by sinks are not under-estimated before the crediting period can be renewed using control plots.

The carbon stock changes in the baseline scenario can be estimated by measuring carbon stock in the above-ground biomass on control plots respectively at the initial stage and at the end of the crediting period. The control plots shall be established outside the project boundary and serve as proxy and accurately reflect the development of the degraded lands in the absence of the project activity. Measuring the carbon stock change in above-ground biomass is sufficient for the purpose of baseline scenario checking.

4. Data to be collected and archived for the estimation of baseline net GHG removals by sinks

Table D: Data to be collected and archived for the estimation of baseline net GHG removals by sinks

ID number	Data Variable	Source of data	Data Unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.3.01	National, local and sectoral policies that may influence land use in the absence of the proposed A/R CDM project activity	Various	n.a.	Collected	Start and end of the crediting period	As complete as possible	
2.3.02	Natural and anthropogenic factors influencing land use, land cover and natural regeneration	Various	n.a.	Collected	Start and end of the crediting period	As complete as possible	
2.3.03	Stratum ID	Stratification map	Alpha numeric		20 years	100%	Stratum identification for baseline scenario checking
2.3.04	Carbon stock in above-ground biomass at the end of the crediting period	Calculated based on baseline plot measure-ment	t CO_2-e. yr^{-1}	c	End of the crediting period	100% of baseline plots	Calculated based on baseline plot measurement for different strata/sub-strata
2.3.05	Carbon stock in above-ground biomass at the start of the crediting period	Calculated based on baseline plot measure-ment	t CO_2-e. yr^{-1}	c	Start of the crediting period	100% of baseline plots	Calculated based on baseline plot measurement for different strata/sub-strata
2.3.06	Baseline carbon stock change in above-ground biomass	Calculated	t CO_2-e. yr^{-1}	c	20 years	100%	Calculated

5. Calculation of *ex post* actual net GHG removal by sinks

The actual net greenhouse gas removals by sinks represent the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary, minus the increase in GHG emissions measured in CO_2 equivalents by the sources that are increased as a result of the implementation of an A/R CDM project activity, while avoiding double counting, within the project boundary, attributable to the A/R CDM project activity. The calculations can be performed annually or periodically according to the monitoring plan. Therefore:[25]

$$C_{ACTUAL} = \Delta C_{LB} - GHG_E \qquad \textbf{(63)}$$

where:

C_{ACTUAL}	Actual net greenhouse gas removals by sinks; t CO_2-e
ΔC_{LB}	Sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e
GHG_E	Sum of the increases in GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity; t CO_2-e

Note: In this methodology equation 66 is used to estimate actual net greenhouse gas removal by sinks for the period of time elapsed between project start (*t=1*) and the year *t=t*, t** being the year for which actual net greenhouse gas removals by sinks are estimated. The 'stock change' method should be used to determine annual or periodical values.

$$\Delta C_{P,LB} = \Delta C_{P,LB_T} - E_{biomassloss} \qquad \textbf{(64)}$$

where:

$\Delta C_{P,LB}$	Sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e
$\Delta C_{P,LB\ T}$	Sum of the changes in living tree biomass carbon stocks (above- and below-ground); t CO_2-e
$E_{biomassloss}$	Decrease in the carbon stock in the living biomass carbon pools of non-tree vegetation in the year of site preparation, up to time *t**; t CO_2-e (as per equation 15)

5.1 Estimation of changes in the carbon stocks

The carbon stock changes in pools of soil organic carbon, litter and dead wood are ignored in this methodology, thus, the verifiable changes in carbon stock equal to the carbon stock changes in above-ground biomass and below-ground biomass within the project boundary, estimated using the following methods and equations:[26]

$$\Delta C_{P,LB_T} = \sum_{t=1}^{t^*} \sum_{i=1}^{S_{ps}} \sum_{k=1}^{K} \Delta C_{P,ikt} \qquad \textbf{(65)}$$

[25] IPCC GPG-LULUCF Equation 3.2.1.

[26] IPCC GPG-LULUCF Equation 3.2.3.

where:

$\Delta C_{P,LB}$ Sum of the changes in living biomass carbon stocks (above- and below-ground); t CO_2-e

$\Delta C_{P,ikt}$ Annual carbon stock change in living biomass for stratum *i,* stand model *k*, time *t;* t CO_2-e yr^{-1}

i 1, 2, 3*,* ... S_{ps} strata of the project activity

k 1, 2, 3, … *K* stand models

t 1, 2, 3, ...*t** years elapsed since the start of the A/R project activity

and

$$\Delta C_{P,ikt} = (\Delta C_{AB,ikt} + \Delta C_{BB,ikt}) \cdot \frac{44}{12} \tag{66}$$

where:

$\Delta C_{P,ikt}$ Annual carbon stock change in living biomass for stratum *i,* stand model *k*, time *t;* t CO_2-e. yr^{-1}

$\Delta C_{AB,ikt}$ Annual carbon stock change in above-ground biomass for stratum *i,* stand model *k*, time *t;* t C yr^{-1}

$\Delta C_{BB,ikt}$ Annual carbon stock change in below-ground biomass for stratum *i,* stand model *k*, time *t;* t C yr^{-1}

The mean change in carbon stocks in above-ground biomass and below-ground biomass per unit area are estimated based on field measurements on permanent plots. Two methods are available: Biomass Expansion Factors (BEF) method and Allometric Equations method.

BEF Method

Step 1: Measure the diameter at breast height (DBH, at 1.3 m above-ground) and preferably height of all the trees in the permanent sample plots above a minimum DBH. The minimum DBH varies depending on tree species and climate, for instance, the minimum DBH may be as small as 2.5 cm in arid environments where trees grow slowly, whereas it could be up to 10 cm for humid environments where trees grow rapidly (IPCC GPG-LULUCF).

Step 2: Estimate the volume of the commercial component of trees based on locally derived equations, then sum for all trees within a plot and express as volume per unit area (e.g., m^3/ha). It is also possible to combine Step 1 and Step 2 if there are field instruments (e.g. relascope) that measure volume of each tree directly.

Step 3: Choose BEF and root-shoot ratio: The BEF and root-shoot ratio vary with local environmental conditions, species and age of trees, the volume of the commercial component of trees. These parameters can be determined by either developing a local regression equation or selecting from national inventory, Annex 3A.1 Table 3A.1.10 of IPCC GPG LULUCF, or from published sources. If a significant amount of effort is required to develop local BEFs and root-shoot ratios, involving, for instance, harvest of trees, then it is recommended not to use this method but rather to use the resources to develop local allometric equations as described in the allometric method below (refers to Chapter 4.3 in IPCC GPG LULUCF). If that is not possible either, national species specific defaults are for BEF and R can be used. Since both BEF and the root-shoot ratio are age dependent, it is desirable to use age-dependent equations. Stem-wood volume can be very small in young stands and BEF can be very large, while for old stands BEF is usually significantly smaller. Therefore using

average BEF value may result in significant errors for both young stands and old stands. It is preferable to use allometric equations, if the equations are available, and as a second best solution, to use age-dependent BEFs (but for very young trees, multiplying a small number for stemwood with a large number for the BEF can result in significant error).

Step 4: Converting the volume of the commercial component of trees into carbon stock in above-ground biomass and below-ground biomass via basic wood density, BEF root-shoot ratio and carbon fraction, given by:[27]

$$MC_{AB,ijt} = MV_{ijt} \cdot D_j \cdot BEF_j \cdot CF_j \quad \textbf{(67)}$$

$$MC_{BB,ijt} = MC_{AB,ijt} \cdot R_j \quad \textbf{(68)}$$

where:

$MC_{AB,ijt}$	Mean carbon stock in above-ground biomass per unit area for stratum *i,* species *j*, time *t;* t C ha^{-1}
$MC_{BB,ijt}$	Mean carbon stock in below-ground biomass per unit area for stratum *i,* species *j*, time *t;* t C ha^{-1}
MV_{ijt}	Mean merchantable volume per unit area for stratum *i,* species *j*, time *t;* m^3 ha^{-1}
D_j	Volume-weighted average wood density; t d.m. m^{-3} merchantable volume
BEF_j	Biomass expansion factor for conversion of biomass of merchantable volume to above-ground biomass; dimensionless
CF_j	Carbon fraction; IPCC default value = 0.5; t C (t d.m.)$^{-1}$
R_j	Root-shoot ratio; dimensionless

Step 5*:* The total carbon stock in living biomass for stratum *i,* species *j*, time *t* is calculated from the area for stratum *i,* species *j*, time *t* and the mean carbon stocks in above-ground biomass and below-ground biomass per unit area, as follows:

$$C_{AB,ikt} = A_{ikt} \cdot MC_{AB,ikt} \quad \textbf{(69)}$$

$$C_{BB,ikt} = A_{ikt} \cdot MC_{BB,ikt} \quad \textbf{(70)}$$

where:

$\Delta C_{AB,ijt}$	Annual carbon stock change in above-ground biomass for stratum *i,* species *j*, time *t;* t C yr^{-1}
$\Delta C_{BB,ijt}$	Annual carbon stock change in below-ground biomass for stratum *i,* species *j*, time *t;* t C yr^{-1}
A_{ijt}	Area of stratum *i,* species *j*, at time *t*; hectare (ha)

Note: The area of a stratum *i* planted with species *j* in stand model *k* has a time notation because stands with species *j* will be established (planted) at different dates.

$MC_{AB,ijt}$	Mean carbon stock in above-ground biomass per unit area for stratum *i,* species *j*, time *t;* t C ha^{-1}

[27] IPCC GPG-LULUCF Equation 4.3.1.

$MC_{BB,ijt}$ Mean carbon stock in below-ground biomass per unit area for stratum *i,* species *j*, time *t;* t C ha^{-1}

Step 6*:* The change in carbon stock in living biomass over time is given by:

$$\Delta C_{AB,ikt} = \frac{\sum_{j=1}^{J}(C_{AB,ikt_2} - C_{AB,ikt_1})}{T} \quad \textbf{(71)}$$

$$\Delta C_{BB,ikt} = \frac{\sum_{j=1}^{J}(C_{BB,ikt_2} - C_{BB,ikt_1})}{T} \quad \textbf{(72)}$$

where:

$\Delta C_{AB,ikt}$	Annual carbon stock change in above-ground biomass for stratum *i,* stand model *k*, time *t;* t C yr^{-1}
$\Delta C_{BB,ikt}$	Annual carbon stock change in below-ground biomass for stratum *i,* stand model *k*, time *t;* t C yr^{-1}
$C_{AB,ijt2}$	Carbon stock in above-ground biomass for stratum *i,* species *j*, calculated at time $t = t_2$; t C
$C_{AB,ijt1}$	Carbon stock in above-ground biomass for stratum *i,* species *j*, calculated at time $t = t_1$; t C
$C_{BB,ijt2}$	Carbon stock in below-ground biomass for stratum *i,* species *j*, calculated at time $t = t_2$; t C
$C_{BB,ijt1}$	Carbon stock in below-ground biomass for stratum *i,* species *j*, calculated at time $t = t_1$; t C
T	Number of years between monitoring time t_2 and t_1 ($T = t_2 - t_1$); years
j	Species *j* (*J* = total number of species)

Allometric method

Step 1: Measure the diameter at breast height (DBH, at 1.3 m above ground) and possibly, depending on the form of the equation, height of all the trees in the permanent sample plots above a minimum DBH. The minimum DBH varies depending on tree species and climate, for instance, the minimum DBH may be as small as 2.5 cm in arid environments where trees grow slowly, whereas it could be up to 10 cm for humid environments where trees grow rapidly (IPCC GPG-LULUCF).

When first measured all trees should be tagged to permit the tracking of individual trees in plots through time.

Where a tree has died, been harvested or can not be found then the biomass at time t_2 should be made equal to zero to give the requisite deduction.

Step 2: Choose or establish appropriate allometric equations.

$$TB_{ABj} = f_j(DBH, H) \quad \textbf{(73)}$$

where:

TB_{ABj} Above-ground biomass of a tree; kg tree^{-1}

$f_j(DBH,H)$ An allometric equation for species *j* linking above-ground tree biomass (kg tree^{-1}) to diameter at breast height (*DBH*) and possibly tree height (*H*) measured in plots for stratum *i,* species *j*, time *t*

The allometric equations are preferably local-derived and species-specific. When allometric equations developed from a biome-wide database, such as those in Annex 4A.2, Tables 4.A.1 and 4.A.2 of IPCC GPG LULUCF, conservative estimates shall be ensured. The respective procedures and assumptions have to be described in the monitoring plan of the PDD.

Also generic allometric equations can be used, as long as it can be proven that they underestimate carbon sequestration.

Step 3: Estimate carbon stock in above-ground biomass per tree using selected allometric equations applied to the tree measurements in Step 1

$$TC_{ABj} = TB_{ABj} \cdot CF_j \quad \textbf{(74)}$$

where:

TC_{AB} Carbon stock in above-ground biomass per tree; kg C tree^{-1}

TB_{ABj} Above-ground biomass of a tree of species *j*; kg tree^{-1}

CF Carbon fraction (IPCC default value = 0.5); t C (t d.m.)$^{-1}$

Step 4: Calculate the increment of above-ground biomass carbon accumulation at the tree level. Calculate by subtracting the biomass carbon at time 2 from the biomass carbon at time 1 for each tree.

$$\Delta TC_{ABjT} = TC_{ABj,t2} - TC_{ABj,t1} \quad \textbf{(75)}$$

where:

ΔTC_{ABjT} Carbon stock change in above-ground biomass per tree of species *j* between two monitoring events; kg C tree^{-1}

$\Delta TC_{ABj,t2}$ Carbon stock change in above-ground biomass per tree of species *j* at monitoring event t_2; kg C tree^{-1}

$\Delta TC_{ABj,t1}$ Carbon stock change in above-ground biomass per tree of species *j* at monitoring event t_1; kg C tree^{-1}

Step 5: Calculate the increment in above-ground biomass carbon per plot on a per area basis. Calculate by summing the change in biomass carbon per tree within each plot and multiplying by a plot expansion factor which is proportional to the area of the measurement plot. This is divided by 1,000 to convert from kg to t.

$$\Delta PC_{ABikT} = \frac{XF \cdot \sum_{tr=1}^{TR} \Delta TC_{ABjT,tr}}{1000} \quad \textbf{(76)}$$

$$XF = \frac{10{,}000}{AP} \quad \textbf{(77)}$$

where:

$\Delta PC_{AB,ijT}$ Plot level carbon stock change in above ground biomass in stratum *i*, species *j*, between two monitoring events; t C ha^{-1}

ΔTC_{ABjT} Carbon stock change in above-ground biomass per tree of species *j* between two monitoring events; kg C tree^{-1}

XF Plot expansion factor from per plot values to per hectare values

AP Plot area; m^2

tr Tree (*TR* = total number of trees in the plot)

Step 6*:* Calculate mean carbon stock change within each stratum. Calculate by averaging across plots in a stratum or stand:

$$\Delta MC_{ABikT} = \frac{\sum_{pl=1}^{PL_{ik}} \sum_{j}^{J} \Delta PC_{ABikT,pl}}{PL_{ik}} \tag{78}$$

where:

ΔMC_{ABikT} Mean carbon stock change in above-ground biomass in stratum *i*, stand model *k*, between two monitoring events; t C ha^{-1}.

ΔPC_{ABijT} Plot level mean carbon stock change in above-ground biomass in stratum *i*, species *j*, between two monitoring events; t C ha^{-1}.

pl Plot number in stratum *i*, species *j*; dimensionless

PL_{ik} Total number of plots in stratum *i*, stand model *k*; dimensionless

j Species *j* (*J* = total number of species)

Step 7: Estimate carbon stock in below-ground biomass using root-shoot ratios and above-ground carbon stock and apply Steps 4 and 5 to below-ground biomass.

$$TC_{BBj} = TC_{ABj} \cdot R_j \tag{79}$$

$$\Delta TC_{BBjT} = TC_{BBj,t2} - TC_{BBj,t1} \tag{80}$$

$$\Delta PC_{BB,ikT} = \frac{XF \cdot \sum_{tr=1}^{TR} \Delta TC_{BBjT}}{1000} \tag{81}$$

$$\Delta MC_{BB,ikT} = \frac{\sum_{pl=1}^{PL_{ik}} \Delta PC_{BBikT,pl}}{PL_{ik}} \tag{82}$$

where:

TC_{BBj}	Carbon stock in below-ground biomass per tree of species *j*; kg C tree^{-1}
TC_{ABj}	Carbon stock in above-ground biomass per tree of species *j* as calculated in Step 1; kg C tree^{-1}
R_j	Root-shoot ratio appropriate to increments for species *j*; dimensionless
ΔTC_{BBjT}	Carbon stock change in below-ground biomass per tree of species *j* between two monitoring events; kg C tree^{-1}
$\Delta PC_{BB,\ ijT}$	Plot level carbon stock change in below-ground biomass of species *j* between two monitoring events; t C ha^{-1}
XF	Plot expansion factor from per plot values to per hectare values (see equation 80); dimensionless
tr	Tree (TR = total number of trees in the plot)
ΔMC_{BBikT}	Mean carbon stock change in below-ground biomass for stratum *i*, stand model *k*, between two monitoring events; t C ha^{-1}
ΔPC_{BBikT}	Plot level carbon stock change in below-ground biomass for stratum *i*, stand model *k*, between two monitoring events; t C ha^{-1} *pl* = plot number in stratum *i*, stand model *k*; dimensionless
PL_{ik}	Total number of plots in stratum *i*, stand model *k*; dimensionless

Step 8: Calculate the annual carbon stock change by dividing the carbon changes between two monitoring events by the number of years between monitoring events.

$$\Delta MC_{ABikt} = \frac{\Delta MC_{ABikT}}{T} \qquad \textbf{(83)}$$

$$\Delta MC_{BBikt} = \frac{\Delta MC_{BBikT}}{T} \qquad \textbf{(84)}$$

where:

$\Delta MC_{AB,ikt}$	Annual mean carbon stock change in above-ground biomass for stratum *i*, stand model *k,* at year *t*; t C ha^{-1} yr^{-1}
$\Delta MC_{BB,ikt}$	Annual mean carbon stock change in below-ground biomass for stratum *i*, stand model *k,* at year *t*; t C ha^{-1} yr^{-1}
ΔMC_{ABikT}	Mean carbon stock change in above-ground biomass for stratum *i*, stand model *k,* between two monitoring events; t C ha^{-1} yr^{-1}
ΔMC_{BBikT}	Mean carbon stock change in below-ground biomass for stratum *i*, stand model *k,* between two monitoring events; t C ha^{-1} yr^{-1}
T	Number of years between two monitoring events which in this methodology is 5 years

Step 9*:* The annual carbon stock change in living biomass for each stratum *i*, species *j*, stand model *k*, at time *t* is calculated from the area of each stratum *i*, species *j*, stand model *k*, at time *t* and the annual mean carbon stock change in above-ground biomass and below-ground biomass per unit area, given by:

$$\Delta C_{AB,ikt} = A_{ikt} \cdot \Delta MC_{AB,ikt} \qquad \textbf{(85)}$$

$$\Delta C_{BB,ikt} = A_{ikt} \cdot \Delta MC_{BB,ikt} \quad \textbf{(86)}$$

where:

A_{ikt} Area of stratum *i*, stand model *k,* at time *t*; hectare (ha)

$\Delta C_{AB,ikt}$ Changes in carbon stock in above-ground biomass for stratum *i*, stand model *k,* at time *t*; t C yr^{-1}

$\Delta C_{BB,ikt}$ Changes in carbon stock in below-ground biomass for stratum *i*, stand model *k,* at time *t*; t C yr^{-1}

$\Delta MC_{AB,ikt}$ Annual mean carbon stock change in above-ground biomass for stratum *i*, stand model *k,* at year *t*; t C ha^{-1} yr^{-1}

$\Delta MC_{BB,ikt}$ Annual mean carbon stock change in below-ground biomass for stratum *i*, stand model *k,* at year *t*; t C ha^{-1} yr^{-1}

Note that stand models will most often be one of the strata, and therefore will be included as such rather than as a separate consideration.

5.2 Estimation of the increase in emissions

The increase in GHG emission as a result of the implementation of the proposed A/R CDM project activity within the project boundary can be estimated by:

$$GHG_E = E_{BiomassBurn} \quad \textbf{(87)}$$

where:

GHG_E Increase in GHG emission as a result of the implementation of the proposed A/R CDM project activity within the project boundary; t CO_2-e

$E_{BiomassBurn}$ Increase in GHG emission as a result of biomass burning within the project boundary; t CO_2-e

Note: In this methodology equation 90 is used to estimate the increase in GHG emission for the period of time elapsed between project start ($t = 1$) and the year $t = t^*$, t^* being the year for which actual net greenhouse gas removals by sinks are estimated.

5.2.1 Estimation of $E_{BiomassBurn}$ (GHG emissions from biomass burning)

Slash and burn or removal of pre-existing vegetation occurs traditionally in some regions during site preparation before planting and/or replanting, this would result in CO_2 and non-CO_2 emissions.

Step 1: Estimating the above-ground biomass stock per unit area before slash and burn or removal. To be conservative this methodology requires that the highest biomass over slash and burn cycles be applied as the baseline and for calculation of emissions from biomass burning. The degraded land or logged land is usually dominated by young trees/seedling, herbaceous plants and shrubs. . A small frame (either circular or square), usually encompassing about 0.5-1.0 m^2 or less, is used to aid this task. The material inside the frame is cut to ground level and weighed. Well-mixed samples are then collected and oven dried to determine dry-to-wet matter ratios. These ratios are then used to convert the entire sample to oven-dry matter. For shrubs and young trees left, destructive harvesting techniques can also be used to measure the above-ground biomass. An alternative approach is to use allometric equations for the trees and shrubs. As long as the trees are larger than the defined minimum diameter for the equation, equations used elsewhere in the project can be applied. For smaller trees it is advised to harvest them with the herbaceous vegetation. If the shrubs are large, it is

possible to develop local shrub allometric equations based on variables such as crown area and height or diameter at base of plant or some other relevant variable (e.g., number of stems in multi-stemmed shrubs). The equations would then be based on regressions of biomass of the shrub versus some logical combination of the independent variables. The independent variable or variables would then be measured in the sampling plots (Refers to Chapter 4.3 in IPCC GPG LULUCF).

Step 2: Estimating mean proportion of biomass burnt (or harvested) and emission factors. The proportion of biomass burnt can be estimated by sampling after burning. The combustion efficiencies may be chosen from Table 3.A.14 of IPCC GPG-LULUCF. If no appropriate combustion efficiency can be used, the IPCC default of 0.5 should be used. The nitrogen-carbon ratio (N/C ratio) is approximated to be about 0.01. This is a general default value that applies to leaf litter, but lower values would be appropriate for fuels with greater woody content, if data are available. Emission factors for use with above equations are provided in Tables 3.A 15 and 3.A.16 of IPCC GPG-LULUCF.

Step 3: Estimating of GHG emissions resulted from the slash and burn based on revised IPCC 1996 Guideline for LULUCF and IPCC GPG-LULUCF:

$$E_{BiomassBurn} = E_{BiomassBurn,CO_2} + E_{BiomassBurn,CH_4} \quad \textbf{(88)}$$

where:

$E_{BiomassBurn}$	Total GHG emission from biomass burning in slash and burn; t CO_2-e
$E_{BiomassBurn,CO2}$	CO_2 emission from biomass burning in slash and burn; t CO_2-e
$E_{BiomassBurn,CH4}$	CH_4 emission from biomass burning in slash and burn; t CO_2-e

and:

$$E_{BiomassBurn,CO_2} = \sum_{t=1}^{t^*}\sum_{i=1}^{m_{PS}}\sum_{k=1}^{K_P}(A_{ikt\_sb} \cdot B_{ikt} \cdot PBB_{ikt} \cdot CE \cdot CF) \cdot \frac{44}{12} \quad \textbf{(89)}$$

where:

A_{ikt_sb}	Area of slash and burn for stratum *i*, stand model *k*, time *t*; ha
B_{ikt}	Average above-ground biomass stock before burning for stratum *i*, stand model *k*, time *t*; t d.m. ha^{-1}
PBB_{ikt}	Average proportion of biomass burnt for stratum *i*, stand model *k*, time *t*; dimensionless
CE	Average biomass combustion efficiency (IPCC default = 0.1); dimensionless
CF	Carbon fraction (IPCC default = 0.5); t C $(t\ d.m.)^{-1}$

$$E_{BiomassBurn,CH_4} = E_{BiomassBurn,CO_2} \cdot \frac{12}{44} \cdot ER_{CH_4} \cdot \frac{16}{12} \cdot GWP_{CH_4} \quad \textbf{(90)}$$

where:[28]

12/44 Ration of molecular weights of carbon and CO_2; dimensionless

16/12 Ration of molecular weights of CH_4 and carbon; dimensionless

ER_{CH4} Emission ratio for CH_4 (IPCC default = 0.012); t CO_2-e./t C

GWP_{CH4} Global Warming Potential for CH_4 (IPCC default = 21 for the first commitment period); t CO_2-e/t CH

[28] Refers to Table 5.7 in 1996 Revised IPCC Guideline for LULUCF and Equation 3.2.19 in IPCC GPG-LULUCF.

6. Data to be collected and archived for actual net GHG removals by sinks

Table E: Data to be collected and archived for actual net GHG removals by sinks

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.01	*DLP*	Desired level of precision (e.g. 10%)		%	Defined	Before the start of the project	100%	For the purpose of QA/QC and measuring and monitoring precision control
2.1.2.02	PBB_{ikt}	Average proportion of biomass burnt for stratum *i*, stand model *k*, time *t*	Measured after slash and burn	Dimensionless	m	Annually	100%	Sampling survey after slash and burn
2.1.1.03	PL_{ID}	Sample plot ID (1, 2, 3, … pl, …)	Project and plot map, GIS	Alpha numeric	Defined	Before the start of the project	100%	Numeric series ID will be assigned to each permanent sample plot
2.1.1.04	PL_{ik}	Total number of plots in stratum *i*, stand model *k*	Field measurement	Dimensionless	m	5-year	100%	
2.1.1.05	R_j	Root-shoot ratio	Local-derived, national inventory,	Dimensionless	e	5 year	100% of sampling plots	Local-derived and species-specific value have the priority
2.1.1.06	*16/12*	Ratio of molecular weights of CH_4 and carbon;	Universal constant	Dimensionless	Universal constant			
2.1.1.07	*44/12*	Ratio of molecular weights of carbon and CO_2; dimensionless	Universal constant	Dimensionless	Universal constant			

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.08	*44/28*	Ratio of molecular weights of N_2O and nitrogen; dimensionless	Universal constant	Dimensionless	Universal constant			
2.1.1.09		Confidence level (e.g. 90%)	AR-CDM-PDD	%	Defined	Before the start of the project	100%	For the purpose of QA/QC and measuring and monitoring precision control
2.1.1.10	A	Total size of all strata (A), e.g. the total project area	GIS or/and GPS	Hectares	m	Before the start of the project and adjusted thereafter every 5-year	100%	
2.1.1.11	A_i	Area of each stratum	GIS or/and GPS	Hectares	m	Before the start of the project and adjusted thereafter every 5-year	100%	
2.1.1.13	A_{ikt}	Area of stratum *i*, stand model *k*, at time *t*;	GIS or/and GPS	Hectares	m	Yearly	100%	Measured for different strata and stands
2.1.1.14	A_{B,ikt_sb}	Area of slash and burn in stratum *i*, stand model *k*, at time *t*	Measurement	Hectares	m	Yearly	100%	Measured for different strata and stands
2.1.1.15	*AP*	Sample plot area	Field measurement	m^2	m	5-year	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.16	*BEF*	Biomass expansion factor (BEF)	Local-derived, national inventory, IPCC GPG LULUCF	Dimensionless	e	5 year	100% of sampling plots	Local-derived and species-specific value have the priority (IPCC default in LULUCF GPG 2003, Table 3A.1.10)
2.1.1.17	B_{ijt}	Average above-ground bio-mass stock before burning for stratum *i*, species *j*, time *t*	Field measurement	t d.m. ha^{-1}	m	Before burning	Sample plots	
2.1.1.18	*N/C ratio*	Nitrogen/carbon ratio	Literature	Dimensionless	e	Once per species or group of species		IPCC default value (0.01) is used if no appropriate value
2.1.1.19	$C_{AB,ijt}$	Carbon stock in above-ground biomass for stratum *i*, species *j*, time *t*	Calculations	t C	c	5-year	100%	
2.1.1.20	C_{ACTUAL}	Actual net greenhouse gas removals by sinks;	Calculations	t CO_2-e.	c	5-year	100%	
2.1.1.21	$C_{BB,ijt}$	Carbon stock in below-ground biomass for stratum *i*, species *j*, time *t*	Calculations	t C	c	5-year	100%	
2.1.1.22	*CE*	Average biomass combustion efficiency	GPG LULUCF, National inventory	Dimensionless	e	Before the start of the project	100%	IPCC default value (0.5) is used if no appropriate value
2.1.1.23	*CF*	Carbon fraction	Local, national, IPCC	t C (t d.m.)$^{-1}$	e	Once per crediting period		Local-derived and species-specific value have the priority (IPCC default = 0.5)

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.24	CF_j	Carbon fraction of species *j*	Local, national, GPG for LULUCF IPCC	t C (t d.m.)$^{-2}$	e	Once per species	100% of species or species group	Local-derived and species-specific value have the priority (IPCC default = 0.5)
2.1.1.25	C_i	Cost of establishment of a sample plot for each stratum *i*	Measurement	US$ or local currency	m	5-years	100%	
2.1.1.28	*DBH*	Diameter at breast height of living and standing dead trees	Plot measurement	cm (living/dead)	m	5 year	100% trees in plots	Measuring at each monitoring time per sampling method
2.1.1.29	D_j	Wood density of species *j*	Local-derived, national inventory, IPCC GPG LULUCF	t d.m. m^{-3}	e	5 year	100% of sampling plots	Local-derived and species-specific value have the priority
2.1.1.30	*D*	Average wood density	Local-derived, national inventory, IPCC GPG LULUCF	t d.m. m^{-3}	e	5 year	100% of sampling plots	Local-derived and species-specific value have the priority
2.1.1.31	*E*	Allowable error	Calculations	Depends on the variable calculated	c	5-year	100% of the variables	
2.1.1.32	$E_{BiomassBurn}$	Increase in GHG emission as a result of biomass burning within the project boundary	Calculations	t CO_2-e.	c	5-year	100%	
2.1.1.33	$E_{BiomassBurn, CH4}$	CH_4 emission from biomass burning in slash and burn	Calculations	t CO_2-e.	c	5-year	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.34	$E_{BiomassBurn, N2O}$	N_2O emission from biomass burning in slash and burn	Calculations	t CO_2-e.	c	5-year	100%	
2.1.1.35	$E_{BiomassBurn,CO2}$	CO_2 emission from biomass burning in slash and burn	Calculations	t CO_2-e.	c	5-year	100%	
2.1.1.40	ER_{N20}	Emission ratio for N_2O	Literature	Dimensionless	e	Yearly		(IPCC default = 0.007)
2.1.1.41	ER_{CH4}	Emission ratio for CH_4	Literature	Dimensionless	e	Yearly		(IPCC default = 0.012)
2.1.1.42	$f_j(DBH,H)$	Allometric equation for species *j* linking above-ground tree biomass (kg $tree^{-1}$) to diameter at breast height (DBH) and possibly tree height (H) measured in plots for stratum *i*, species *j*, time *t*	Literature and/or field measurements	kg $tree^{-1}$	m-e-c	Once per species	for all major species or group of species	Use local/global equations validated for local conditions
2.1.1.46	GHG_E	Increase in GHG emission as a result of the implementation of the proposed A/R CDM project activity within the project boundary	Calculations	t CO_2-e	c	5-year	100%	
2.1.1.47	GWP_{CH4}	Global Warming Potential for CH_4	IPCC literature - EB decisions		e	Once per commitment period		(IPCC default = 21)
2.1.1.48	GWP_{N2O}	Global Warming Potential for N_2O	IPCC literature - EB decisions		e	Once per commitment period		(IPCC default = 310)

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.49	H_{ijt}	Annually harvested volume and fuel wood for stratum *i*, species *j*, at time *t*	Harvesting statistics	m^3	c	Annually	100% stands	Annually recorded
2.1.1.50	i_{ID}	Stratum *i*D (1, 2, 3, … m_{SP} project scenario (*ex post*) strata)	Stand map, GIS	Alpha numeric	Defined	At stand establishment	100%	Each stand has a particular year to be planted under each stratum
2.1.1.51	ID_{ikt}	Stand ID	Stand map, GIS	Alpha numeric	Defined	At stand establishment	100%	Each stand has a particular year to be planted under each stratum
2.1.1.52	*lat/long*	Plot location	Project and plot map and GPS locating, GIS		m	5 years	100%	Using GPS to locate before start of the project and at time of each field measurement
2.1.1.53	$MC_{AB,ijt}$	Mean carbon stock in above-ground biomass per unit area for stratum *i*, species *j*, time *t*	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.54	$MC_{BB,ijt}$	Mean carbon stock in below-ground biomass per unit area for stratum *i*, species *j*, time *t*	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.55	MV_{ijt}	Mean merchantable volume per unit area for stratum *i*, species *j*, time *t*		m^3 ha^{-1}	m^3	5 year	100% of sampling plots	Calculated from 2.1.1.13 and possibly 2.1.1.15 using local-derived equations, or directly measured by field instrument
2.1.1.56	*N*	Maximum possible number of sample plots in the project area	Calculations	Dimensionless	c	5-years	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.57	n	Sample size (total number of sample plots required) in the project area	Calculations	Dimensionless	c	5-years	100%	
2.1.1.58	N_i	Maximum possible number of sample plots in stratum *i*	Calculations	Dimensionless	c	Before the start of the project and adjusted thereafter every 5-year	100%	
2.1.1.59	n_i	Sample size for stratum *i*	Calculations	Dimensionless	c	Before the start of the project and adjusted thereafter every 5-year	100%	Calculated for each stratum
2.1.1.64	nTR_{PLikt}	Number of trees in the sample plot	Plot measurement	Number	m	5 years	100% trees in plots	Counted in plot measurement
2.1.1.66	*DLP*	Desired level of precision (e.g. 10%)		%	Defined	Before the start of the project	100%	For the purpose of QA/QC and measuring and monitoring precision control
2.1.1.67	PBB_{ikt}	Proportion of biomass burnt	Measured after slash and burn	Dimensionless	m	Annually	100%	Sampling survey after slash and burn
2.1.1.68	PBB_{ikt}	Average proportion of biomass burnt for stratum *i*, stand model *k*, time *t*	Field estimates or literature	Dimensionless	e	Before burning	Sample plots	Used for estimating numbers of sample plots of each stratum and stand, as necessary

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.69	PL_{ID}	Sample plot ID (1, 2, 3, … pl, …)	Project and plot map, GIS	Alpha numeric	Defined	Before the start of the project	100%	Numeric series ID will be assigned to each permanent sample plot
2.1.1.70	PL_{ik}	Total number of plots in stratum *i*, stand model *k*	Field measurement	Dimensionless	m	5-year	100%	
2.1.1.71	R_j	Root-shoot ratio	Local-derived, national inventory	Dimensionless	e	5 year	100% of sampling plots	Local-derived and species-specific value have the priority
2.1.1.72	st_i	Standard deviation for each stratum *i*; dimensionless			e	At each monitoring event	100%	Used for estimating numbers of sample plots of each stratum and stand, as necessary
2.1.1.73	TB_{ABj}	Above-ground biomass of a tree	Calculations	kg dry matter tree^{-1}	c	5-year	100%	
2.1.1.74	TC_{ABj}	Carbon stock in above-ground biomass per tree of species *j*	Calculations	kg C tree^{-1}	c	5-year	100%	
2.1.1.75	*tID*	Age of plantation (1, 2, 3, … years)	GIS	year	m	At stand establishment	100%	Counted since the planted year
2.1.1.76	tr_{ID}	Tree ID (1, 2, 3, … tr … TR = total number of trees in the plot)	Field measurement	Dimensionless	m	5-year	100%	
2.1.1.77	*XF*	Plot expansion factor from per plot values to per hectare values)	Calculations	Dimensionless	c	5-year	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.78	$z_{\alpha/2}$	Value of the statistic z (normal probability density function), for α = 0.1 (implying a 90% confidence level)	Statistic book	Dimensionless	m	5-years	0%	
2.1.1.79	$\Delta C_{AB,ijt}$	Annual carbon stock change in above-ground biomass for stratum *i*, species *j*, time *t*;	Calculations	$t\ C\ yr^{-1}$	c	5-year	100%	
2.1.1.80	$\Delta C_{AB,ikt}$	Annual carbon stock change in above-ground biomass for stratum *i*, stand model *k*, time *t*;	Calculations	$t\ C\ yr^{-1}$	c	5-year	100%	
2.1.1.81	$\Delta C_{BB,ijt}$	Annual carbon stock change in below-ground biomass for stratum *i*, species *j*, time *t*;	Calculations	$t\ C\ yr^{-1}$	c	5-year	100%	
2.1.1.82	$\Delta C_{BB,ikt}$	Annual carbon stock change in below-ground biomass for stratum *i*, stand model *k*, time *t*;	Calculations	$t\ C\ yr^{-1}$	c	5-year	100%	
2.1.1.83	$\Delta C_{LB,ikt}$	Annual carbon stock change in living biomass for stratum *i*, stand model *k*, time *t*	Calculations	$t\ CO_2\text{-e.}\ yr^{-1}$	c	5-year	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.84	$\Delta C_{P,LB}$	Sum of the changes in living biomass carbon stocks (above- and below-ground)	Calculations	t CO_2-e	c	5-year	100%	
2.1.1.85	ΔMC_{ABikT}	Mean carbons stock change in above-ground biomass stratum *i*, stand model *k*, between two monitoring events	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.86	ΔMC_{ABikt}	Mean carbons stock change in above-ground biomass stratum *i*, stand model *k*, between two monitoring events	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.87	$\Delta MC_{BB,ikt}$	Mean carbons stock change in below-ground biomass stratum *i*, stand model *k*	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.88	ΔMC_{BBikT}	Mean carbons stock change in below-ground biomass stratum *i*, stand model *k*, between two monitoring events	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.89	$\Delta PC_{AB,ijT}$	Plot level mean carbon stock change in above-ground biomass ins stratum *i*, species *j* between two monitoring events	Calculations	t C ha^{-1}	c	5-year	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.90	$\Delta PC_{BB,ijT}$	Plot level mean carbon stock change in above-ground biomass in stratum *i*, species *j* between two monitoring events	Calculations	t C ha^{-1}	c	5-year	100%	
2.1.1.91	ΔTC_{ABjt}	Carbon stock change in above-ground biomass per tree of species *j* in year *t*	Calculations	kg C $tree^{-1}$	c	5-year	100%	
2.1.1.92	ΔTC_{ABjT}	Carbon stock change in above-ground biomass per tree of species *j* between two monitoring events	Calculations	kg C $tree^{-1}$	c	5-year	100%	
2.1.1.93	ΔTC_{BBjt}	Carbon stock change in below-ground biomass per tree of species *j* in year *t*	Calculations	kg C $tree^{-1}$	c	5-year	100%	
2.1.1.94	ΔTC_{BBjT}	Carbon stock change in below-ground biomass per tree of species *j* between two monitoring events	Calculations	kg C $tree^{-1}$	c	5-year	100%	

7. Leakage

For the type of A/R CDM project activity to which this methodology applies, leakage shall be estimated as follows:

$$LK = LK_{ActivityDisplacement} \quad \textbf{(91)}$$

Note: In this methodology equation 95 is used to estimate leakage for the period of time elapsed between project start (*t=1*) and the year *t=t**, *t** being the year for which actual net greenhouse gas removals by sinks are estimated.

7.1 Estimation of $LK_{ActivityDisplacement}$ (leakage due to activity displacement)

Leakage due to activity displacement is estimated as follows:

$$LK_{Activitydisplacement} = LK_{conversion} + LK_{fuelwood} \quad \textbf{(92)}$$

where:

$LK_{ActivityDisplacement}$	Leakage due to activity displacement; t CO_2-e
$LK_{conversion}$	Leakage due to conversion of forest to non-forest; t CO_2-e
$LK_{fuel\text{-}wood}$	Leakage due to the displacement of fuel-wood collection; t CO_2-e

As a result of the A/R CDM project activity, agricultural activities may be displaced permanently or temporarily outside the project boundary. This 'activity shifting' or 'activity displacement' may result in leakage in the immediate years after the start of the project activity when activities are displaced to areas outside the project boundary. $LK_{conversion}$ occurs in two ways:

(a) Conversion for grazing;

(b) Conversion for cropland.

Therefore:

$$LK_{conversion} = LK_{conv-graz} + LK_{conv-crop} \quad \textbf{(93)}$$

where:

$LK_{conv\text{-}graz}$	Leakage resulting from the conversion for grazing
$LK_{conv\text{-}crop}$	Leakage resulting from the conversion for cropland

7.1.1 Estimation of $LK_{conv\text{-}graz}$ (Leakage due to conversion of land to grazing land)

Leakage due to conversion of land to grazing land is not attributable to the A/R CDM project activity if the conversion of land to grazing land occurs 5 years after the last measure taken to reduce animal populations in the project area. Monitoring of leakage due to the conversion of land to grazing land is therefore necessary only up to the fifth year after the last measure taken to reduce animal populations in the project area.

Step 1: Monitor the grazing control measures specified in the AR-CDM-PDD. This is necessary to establish the actual date of the last measure taken to control animal grazing. Monitoring of leakage due to conversion of land to grazing land will not be necessary 5 years after this date because any conversion of land to grazing land would not be reasonably attributable to the A/R CDM project activity.

Step 2: For each verification period, estimate the average animal population size present in the project area to estimate the number of animals displaced outside the project boundary. Monitoring can be done by periodically surveying the project area or a randomly selected sample of discrete areas as part of the project area and by interviewing the animal owners.

$$Na_{outside,t} = Na_{BL} - Na_{AR,t} \quad \textbf{(94)}$$

where:

$Na_{outside,t}$ Number of animals displaced outside the project area at year t; dimensionless

Na_{BL} *Ex ante* estimated pre-project number of animals from the different livestock groups that would be grazing in the project area under the baseline scenario; dimensionless. This estimate is fixed for the entire crediting period and is specified in the AR-CDM-PDD

$Na_{AR,t}$ Monitored number of animals present in the project area at year t; dimensionless

If:

- $Na_{BL} < Na_{AR,t}$ then, it can be assumed that the AR-CDM project activity has not displaced grazing animal populations. Leakage due to conversion of land to grazing land can be set as zero ($LK_{conversion} = 0$) and no further monitoring step is needed;
- $Na_{BL} > Na_{AR,t}$ then it is necessary to monitor the animal populations in the *EGL* areas specified in the AR-CDM-PDD.

Step 3: For each verification period, estimate the average animal population size displaced in the *EGL* areas specified in the AR-CDM-PDD by periodically surveying these areas and interviewing their owners.

$$dNa_{EGL,t} = \frac{Na_{EGL,t} - Na_{EGL,t=1}}{SFR_{EGL}} \quad \textbf{(95)}$$

where:

dNa_{EGLt} Number of animals displaced in *EGL* areas at time t; dimensionless

$Na_{EGL,t}$ Number of animals present in the sampled *EGL* areas at time t; dimensionless

$Na_{EGL,t=1}$ Number of animals present in the sampled *EGL* areas at time $t=1$, as specified in the AR-CDM-PDD; dimensionless

SFR_{EGL} Fraction of sampled *EGL* areas sampled with respect to total, as specified in the AR-CDM-PDD; dimensionless

If:

- $Na_{BL} < (Na_{AR,t} + dNa_{EGL,t})$ then, it can be assumed that the animal populations displaced due to the AR CDM project activity have not occasioned leakage due to conversion of land to grazing land ($LK_{conversion} = 0$) and no further monitoring step is needed;
- $Na_{BL} > (Na_{AR,t} + dNa_{EGL,t})$ then it is necessary to monitor the animal populations in the *NGL* areas specified in the AR-CDM-PDD.

Step 4: For each verification period, estimate the average animal population size displaced in the *NGL* areas specified in the AR-CDM-PDD by periodically surveying these areas and interviewing their owners.

$$dNa_{NGL,t} = \frac{Na_{NGL,t} - Na_{NGL,t=1}}{SFR_{NGL}} \quad \textbf{(96)}$$

where:

dNa_{NGLt} Number of animals displaced in *NGL* areas at time *t*; dimensionless

$Na_{NGL,t}$ Number of animals present in the sampled *NGL* areas at time *t*; dimensionless

$Na_{NGL,t=1}$ Number of animals present in the sampled *NGL* areas at time $t = 1$, as specified in the AR-CDM-PDD; dimensionless

SFR_{NGL} Fraction of sampled *NGL* areas sampled with respect to total, as specified in the AR-CDM-PDD; dimensionless

If:

- $Na_{BL} < (Na_{AR,t} + dNa_{EGL,t} + dNa_{NGL,t})$ then, it can be assumed that AR-CDM project activity has not displaced animal population to unidentified areas and leakage due to conversion of non-grassland to grassland in unidentified *XGL* areas can be set as zero ($LK_{XGL} = 0$);
- $Na_{BL} > (Na_{AR,t} + dNa_{EGL,t} + dNa_{NGL,t})$ then it is necessary to estimate the animal populations displaced in *XGL* areas as follows:

$$dNa_{XGL,t} = Na_{BL} - Na_{AR,t} - dNa_{EGL,t} - dNa_{NGL,t} \quad \textbf{(97)}$$

Step 5*:* Estimate leakage due to displacement of grazing activities as follows:

$$LK_{conv\text{-}graz} = LK_{NGL} + LK_{XGL} \quad \textbf{(98)}$$

where:

LK_{NGL} Leakage due to conversion of non-grassland to grassland in *NGL* areas under the control of the animal owners; t CO_2-e

LK_{XGL} Leakage due to conversion of non-grassland to grassland in unidentified *XGL* areas; t CO_2-e

(a) Estimation of LK_{NGL}

$$LK_{NGL} = dNa_{NGL,t} \cdot aLK_{NGL} \quad \textbf{(99)}$$

where:

LK_{NGL} Leakage due to conversion of non-grassland to grassland in *NGL* areas; t CO_2-e

dNa_{NGLt} number of animals displaced in *NGL* areas at time *t* – as estimated in Step 4; dimensionless

aLK_{NGL} Average leakage due to conversion of non-grassland to grassland per displaced animal in *NGL* areas – as estimated *ex ante* in the AR-CDM-PDD; t CO_2-e. animal^{-1}

(b) Estimation of LK_{XGL}

$$LK_{XGL} = dNa_{XGL,t} \cdot aLK_{XGL} \quad \textbf{(100)}$$

where:

LK_{XGL} Leakage due to conversion of non-grassland to grassland in *XGL* areas; t CO_2-e

dNa_{XGLt} Number of animals displaced in *XGL* areas at time *t* – as estimated in Step 4; dimensionless

aLK_{XGL} Average leakage due to conversion of non-grassland to grassland per displaced animal in *XGL* areas – as estimated *ex ante* in the AR-CDM-PDD; t CO_2-e animal^{-1}

7.1.2 Estimation of $LK_{conv\text{-}crop}$ (Leakage due to conversion of land to crop land, based on area of conversion)

Leakage through land conversion due to activity displacement should be monitored through sampling the households and communities displaced from land by the project. However, leakage due to conversion of land is not attributable to the A/R CDM project activity if the conversion of land occurs 5 or more years after the displacement of the activity to areas outside the project boundary. Leakage estimation includes monitoring households with identifiable areas of land conversion and conservatively applying a deforestation area to households with unidentifiable areas of land conversion. The type and schedule of measures to be taken to prevent conversion of land outside the project boundary should be described in the AR-CDM-PDD and its implementation monitored.

$$LK_{conv\text{-}crop} = CS_{AD} - CS_b \quad \textbf{(101)}$$

where:

CS_{AD} Locally derived carbon stock (including all the five eligible carbon pools; t CO_2-e. ha^{-1}) of area of land on which activities shifted; t CO_2-e ha^{-1}

CS_b Carbon stock of baseline; t CO_2-e ha^{-1}

Case 1: $CS_{AD} < CS_b$

Leakage due to displacement for cropland can be set as zero if the carbon stock on the land to which crops are displaced is less than the carbon stock from which they originated under the baseline scenario.

$$L_{conv\text{-}crop} = 0, \text{ if } CS_{AD} < CS_b \quad \textbf{(102)}$$

Case 2: $CS_{AD} > CS_b$

Step 0: Determine if leakage analysis will take place at the household or community level. Household level analysis should only take place in project areas where households have clear land ownership or tenure.

(a) Household level

T_0: Before start of project activities

Step 1: Record the number of households occupying land inside the project boundary (*TNHH*). Randomly select 10% of the households (or a minimum of 30) to be sampled.

Step 2: Measure area of land within project boundaries each sampled household will be displaced from due to project activities ($TACP_h$).

T_1: Return one year after activity displacement and record land conversion outside project area

Step 3: Classify sampled households as either having identifiable or unidentifiable converted lands. Households which have moved from the area or which cannot be found should be placed in the 'unidentifiable households' category.

Step 4: Measure area of identifiable land each household has converted since displacement of pre-project activities (IAC_{hi}).

Step 5: Classify each area of identifiable converted land into a pre-conversion land cover stratum.

Step 6: Measure the carbon stock (including all 5 pools) in each land cover stratum using methods from IPCC GPG-LULUCF chapter 4.3.

Step 7: Determine the mean conservative forest biomass stock for the project region ($\overline{CS}$), if no mean regional stock data exists, use mean national stock reported in IPCC GPG-LULUCF (Table 3A.1.4).

Step 8: Calculate the leakage using the following equations:

$$LK_{conv-crop} = \sum_{hh=1}^{Hh}\left(\sum_{i=1}^{I} IAC_{hi} \cdot CS_i\right) \cdot SF + \sum_{hh=1}^{Hh}\left(TACP_h - \sum_{i=1}^{I} IAC_{hi}\right) \cdot \overline{CS} \cdot SF \qquad \textbf{(103)}$$

and:

$$SF = \frac{TNHH}{SHH} \qquad \textbf{(104)}$$

where:

$LK_{conv-crop}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting); t CO_2-e
IAC_{hi}	Identifiable areas converted by household *hh* in stratum *i*; hectares
$TACP_h$	Total area of cropland planted that is owned by household *hh*; hectares
hh	1,2,3….*Hh* households; dimensionless
i	1,2,3….*I* strata; dimensionless
CS_i	Locally derived carbon stock of identified lands (including all the five eligible carbon pools) of stratum *i*; t CO_2-e ha^{-1}
$\overline{CS}$	Locally derived average carbon stock of unidentified lands (including all five eligible carbon pools); t CO_2-e ha^{-1}
SF	Sampling factor of household; dimensionless

TNHH Total number of households using project lands in baseline; dimensionless

SHH sampled households, number of households sampled for $LK_{conv-crop}$; dimensionless

T_5: Return after *five years and record land conversion outside project area by repeating Steps 3-8.*

(b) Community level

T_0: Before start of project activities:

Step 1: Record the number of communities occupying land inside the project boundary. Randomly select 10 % of the communities (or a minimum of 10 communities) to be sampled.

Step 2: Measure total area of cropland within project boundaries from which pre-project activities in each sampled community will be displaced ($TACP_c$).

Step 3: Calculate the total number of households within each selected community (TNHHc).

Step 4: Randomly select 10 % of households (or a minimum of 10 households) to be sampled within selected communities.

T_1: Return one year after activity displacement and record land conversion outside project area:

Step 5: Interview community members to estimate the area of identifiable land that each sampled community will convert due to displacement of pre-project activities (IAC_{hc}).

Step 6: Classify the estimated area of identifiable land that may be converted within the community into a pre-conversion land cover stratum.

Step 7: Estimate the carbon stock (including all 5 pools) in each land cover stratum using methods detailed in IPCC GPG-LULUCF chapter 4.3 (CS_i).

Step 8: Determine the mean conservative forest biomass stock for the project region ($\overline{CS}$) for application to unidentified areas.

Step 9: Calculate the leakage using the following equations:

$$LK_{conv-crop,c} = \sum_{hh=1}^{Hh_c}\left(\sum_{i=1}^{I} IAC_{hci} \cdot CS_i\right) \cdot SF_c + \sum_{hh=1}^{Hh_c}\left(TACP_c - \sum_{i=1}^{I} IAC_{hci}\right) \cdot \overline{CS} \cdot SF_c \quad \textbf{(105)}$$

$$SF_c = \frac{TNHH_c}{SHH_c} \quad \textbf{(106)}$$

$$LK_{conv-crop} = TACP \cdot \frac{\sum_{c=1}^{C} LK_{conv-crop,c}}{\sum_{c=1}^{C} TACP_c} \quad \textbf{(107)}$$

where:

$LK_{conv\text{-}crop}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting); t CO_2-e
$LK_{conv\text{-}crop,c}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting) in community *c*; t CO_2-e
TACP	Total area of land on which pre-project activities were displaced due to project activities; hectares
$TACP_c$	Total area of land on which pre-project activities were displaced due to project activities in community *c*; hectares
IAC_{hci}	Identifiable areas converted of stratum *i* by household *hh* in community *c*; hectares
CS_i	Locally derived carbon stock (including all eligible carbon pools) of stratum *i*; t CO_2-e. ha^{-1}
$\overline{CS}$	Locally derived average carbon stock of unidentified lands (including all five eligible carbon pools); t CO_2-e. ha^{-1}
$TNHH_c$	Total number of households using project lands in baseline in community *c*; dimensionless
SHH_c	Sampled households in community *c*, number of households sampled for leakage by activity shifting; dimensionless
SF_c	Sampling factor for community *c*; dimensionless
c	1,2,3…*C*, communities; dimensionless
i	1,2,3….*I*, strata; dimensionless
hh	1,2,3, Hh_c, households in community *c;* dimensionless

7.1.3 Estimation of $LK_{fuel\text{-}wood}$ (Leakage due to displacement of fuel-wood collection)

Step 1: For each verification period, estimate the average fuel-wood collection in the project area to estimate the volume of fuel-wood gathering displaced outside the project boundary. Monitoring can be done by periodically interviewing households, through a Participatory Rural Appraisal (PRA) or field-sampling.

$$FG_{outside,t} = FG_{BL} - FG_{AR,t} \qquad \textbf{(108)}$$

where:

$FG_{outside,t}$	Volume of fuel-wood gathering displaced outside the project area at year *t*; m^3 yr^{-1}
FG_{BL}	Average pre-project annual volume of fuel-wood gathering in the project area – estimated *ex ante* and specified in the AR-CDM-PDD; m^3 yr^{-1}
$FG_{AR,t}$	Volume of fuel-wood gathered in the project area according to monitoring results; m^3 yr^{-1}

Step 2: In the *NGL* areas specified in the AR-CDM-PDD for monitoring of displaced animal grazing, monitor the volume of fuel-wood gathering that is supplied to pre-project fuel-wood collectors and/or charcoal producers ($FG_{NGL,t}$).

Step 3: Leakage due to displacement of fuel-wood collection can be set as zero ($LK_{fuel\text{-}wood} = 0$) under the following circumstances:

- $FG_{BL} < FG_{AR,t}$;

- $LK_{fuel\text{-}wood}$< 2% of actual net GHG removals by sinks (See EB 22, Annex 15).

If one of the above assumptions was made in the AR-CDM-PDD, it is necessary to monitor FG_{ARt} and/or FG_{NGLt} to prove that the assumption is still valid.

In all other cases, leakage due to displacement of fuel-wood collection shall be estimated as follow (IPCC GPG-LULUCF - Equation 3.2.8):

$$LK_{fuel-wood} = \sum_{t=1}^{t^*} FG_t \cdot D \cdot BEF_2 \cdot CF \cdot \frac{44}{12} \qquad \textbf{(109)}$$

$$FG_t = FG_{outside,t} - FG_{NGL,\,t} \qquad \textbf{(110)}$$

where:

$LK_{fuel\text{-}wood}$	Leakage due to displacement of fuel-wood collection up to year t*; t CO_2-e
FG_t	Volume of fuel-wood gathering displaced in unidentified areas; m^3 yr^{-1}
$FG_{outside,t}$	Volume of fuel-wood gathering displaced outside the project area at year t – as per Step 1; m^3 yr^{-1}
$FG_{NGL,t}$	Monitored volume of fuel-wood gathering in *NGL* areas and supplied to pre-project fuel-wood collectors and/or charcoal producers – as per Step 2; m^3 yr^{-1}
D	Average basic wood density; t d.m. m^{-3} (See IPCC GPG-LULUCF - Table 3A.1.9)
BEF_2	Biomass expansion factor for converting volumes of extracted round-wood to total above-ground biomass (including bark); dimensionless Table 3A.1.10
CF	Carbon fraction of dry matter (default = 0.5); t C (t d.m.)$^{-1}$
44/12	Ratio of molecular weights of carbon and CO_2; dimensionless

8. Data to be collected and archived for leakage

Table F: Data to be collected and archived for leakage

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.01	*44/12*	Ration of molecular weights of carbon and CO_2; dimensionless	Universal constant	Dimensionless	Universal constant			
3.1.02	aLK_{NGL}	Average leakage due to conversion of non-grassland to grassland per displaced animal in *NGL* areas	AR-CDM-PDD	t CO_2 -e. animal^{-1}	c - e	*Ex ante* in AR-CDM-PDD	SFR_{NGL}	*Ex ante* estimate in the AR-CDM-PDD
3.1.03	aLK_{XGL}	Average leakage due to conversion of non-grassland to grassland per displaced animal in *XGL* areas	AR-CDM-PDD	t CO_2 -e. animal^{-1}	c - e	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.05	BEF_2	Biomass expansion factor (BEF)	Local-derived, national inventory, IPCC GPG LULUCF	Dimensionless	e	5 year	100% of sampling plots	Local-derived and species-specific value have the priority (IPCC default in LULUCF GPG 2003, Table 3A.1.10)
3.1.06	*c*	Community index (*C*=total number of communities)		Dimensionless	Defined	Years 0, 1 and 5		

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.07	CF_j	Carbon fraction of dry matter of species *j*	Literature, own studies	t C (t d.m.)$^{-1}$	e	Once per species or group of species	100%	Local/national data or IPCC default (= 0.5)
3.1.08	CS_i	Locally derived carbon stock of identified lands (including all five eligible carbon pools) of stratum *i*	Field measurement	t CO_2-e. ha^{-1}	m	Years 0, 1 and 5		
3.1.09	$\overline{CS}$	Locally derived average carbon stock of unidentified lands (including all five eligible carbon pools)	Field measurement	t CO_2-e. ha^{-1}	m	Years 0, 1 and 5		
3.1.11	*Dj*	Wood density of species *j*	Local-derived, national inventory, IPCC GPG LULUCF	t d.m. m^{-3}	e	5 year	100% of sampling plots	Locally derived and species-specific value have the priority
3.1.12	dNa_{EGLt}	Number of animals displaced in *EGL* areas at time *t*	Calculations	Dimensionless	c	Yearly	100%	
3.1.13	dNa_{NGLt}	Number of animals displaced in *NGL* areas at time *t* – as estimated in Step 4	Calculations	Dimensionless	c	Yearly	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.14	dNa_{XGLt}	number of animals displaced in *XGL* areas at time *t* – as estimated in Step 4	Calculations	Dimensionless	c	Yearly	100%	
3.1.17	$FG_{AR,t}$	Volume of fuel-wood gathered in the project area according to monitoring results	Field sampling	$m^3 yr^{-1}$	m	Yearly	SFR_{PAfw}	
3.1.18	FG_{BL}	Average pre-project annual volume of fuel-wood gathering in the project area – estimated *ex ante* and specified in the AR-CDM-PDD	AR-CDM-PDD	$m^3 yr^{-1}$	c - e	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.19	$FG_{NGL,t}$	Monitored volume of fuel-wood gathering in *NGL* areas and supplied to pre-project fuel-wood collectors and/or charcoal producers – as per Step 2	Field measurements	$m^3 yr^{-1}$	m	Yearly	SFR_{NGL}	
3.1.20	$FG_{outside,t}$	Volume of fuel-wood gathering displaced outside the project area at year *t* – as per Step 1	Calculations	$m^3 yr^{-1}$	c	Yearly	100%	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.21	FG_t	Volume of fuel-wood gathering displaced in unidentified areas	Calculations	m^3 yr^{-1}	c	Yearly	100%	
3.1.24	*hh*	Household index (*Hh*=total number of households)			Defined	Years 0, 1 and 5		
3.1.25	*i*	Strata index (*S*=total number of strata)		Dimensionless	Defined	Years 0, 1 and 5		
3.1.26	IAC_{hi}	Identifiable areas converted by household *hh* in stratum *I*	Field measurement	ha	m	Years 0, 1 and 5	10% or at least 30 households	
3.1.27	IAC_{hci}	Identifiable areas converted of stratum *i*, by household *hh* in community *c*	Field measurement	ha	m	Years 0, 1 and 5	10% or at least 30 households	
3.1.29	*LK*	Total project leakage	Calculations	t CO_2-e.	c	Yearly	100%	
3.1.30	$LK_{fuel\text{-}wood}$	Leakage due to the displacement of fuel-wood collection	Calculations	t CO_2-e.	c	Yearly	100%	
3.1.31	$LK_{ActivityDisplacement}$	Leakage due to activity displacement	Calculations	t CO_2-e.	c	Yearly	100%	
3.1.32	$LK_{conversion}$	Leakage due to conversion of forest to non-forest; t CO_2-e.	Calculations	t CO_2-e.	c	Yearly	100%	
3.1.33	$LK_{conv\text{-}graz}$	Leakage resulting from the conversion for grazing	Calculations	t CO_2-e.	c	Yearly		

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.34	$LK_{conv\text{-}crop}$	Leakage resulting from the conversion for cropland	Calculation	t CO_2-e.	c	Years 0, 1 and 5	10% or at least 30 households or 10% of communities (or at least 10), 10% of households per community or at least 10	
3.1.35	$LK_{conv\text{-}crop,c}$	Leakage due to conversion of land to cropland attributable to displacement (activity shifting) in community c	Calculation	t CO_2-e.	c	Years 0, 1 and 5	10% of communities (or at least 10), 10% of households per community or at least 10	
3.1.37	LK_{NGL}	Leakage due to conversion of non-grassland to grassland in NGL areas	Calculations	t CO_2-e.	c	Yearly	100%	
3.1.42	LK_{XGL}	Leakage due to conversion of non-grassland to grassland in *XGL* areas	Calculations	t CO_2-e.	c	Yearly	100%	
3.1.43	$Na_{AR,t}$	Monitored number of animals present in the project area at year *t*	Field measurements	Dimensionless	m	Yearly	SFR_{PAga}	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.44	Na_{BL}	Eex *ante* estimated pre-project number of animals from the different livestock groups that would be grazing in the project area under the baseline scenario	AR-CDM-PDD	Dimensionless	e	*Ex ante* in AR-CDM-PDD	SFR_{PAga}	This estimate is fixed for the entire crediting period and is specified in the AR-CDM-PDD
3.1.45	$Na_{EGL,t}$	Number of animals present in the sampled *EGL* areas at time *t*	Field measurements	Dimensionless	m	Yearly	SFR_{EGL}	
3.1.46	$Na_{EGL,t=1}$	Number of animals present in the sampled *EGL* areas at time *t*=1, as specified in the AR-CDM-PDD	AR-CDM-PDD	Dimensionless	c - e	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.47	$Na_{NGL,t}$	Number of animals present in the sampled *NGL* areas at time *t*	Field measurements	Dimensionless	m	Yearly	SFR_{NGL}	
3.1.48	$Na_{NGL,t=1}$	Number of animals present in the sampled NGL areas at time *t*=1, as specified in the AR-CDM-PDD	AR-CDM-PDD	Dimensionless	c - e	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.49	$Na_{outside,t}$	Number of animals displaced outside the project area at year *t*	Calculations	Dimensionless	c	Yearly	100%	
3.1.52	*SF*	Sampling factor of household *hh*	Calculations	Dimensionless	c	Years 0, 1 and 5	10% or at least 30 households	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.53	SF_c	Sampling factor of household *c*	Calculations	Dimensionless	c	Years 0, 1 and 5	10% or at least 30 households	
3.1.54	SFR_{EGL}	Fraction of sampled *EGL* areas sampled with respect to total	CDM-AR-PDD	Dimensionless	Defined using statistical criteria	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.55	SFR_{NGL}	Fraction of sampled *NGL* areas sampled with respect to total	CDM-AR-PDD	Dimensionless	Defined using statistical criteria	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.56	SFR_P	Fraction of sampled project areas sampled fencing posts	CDM-AR-PDD	Dimensionless	Defined using statistical criteria	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.57	SFR_{PAfw}	Fraction of sampled project areas sampled for fuel-wood collection	CDM-AR-PDD	Dimensionless	Defined using statistical criteria	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.58	SFR_{PAga}	Fraction of sampled project areas sampled for grazing animals	CDM-AR-PDD	Dimensionless	Defined using statistical criteria	*Ex ante* in AR-CDM-PDD		*Ex ante* estimate in the AR-CDM-PDD
3.1.59	*SHH*	Sampled households, number of households	Field measurement	Dimensionless	Defined	Year 0	10% or at least 30 households	

ID number	Data Variable		Source of data	Data unit	Measured (m) calculated (c) estimated (e)	Recording frequency	Proportion of data monitored	Comment
3.1.60	SHH_c	Sampled households in community *c*	Field measurement	Dimensionless	Defined	Year 0	10% of communities (or at least 10), 10% of households per community or at least 10	
3.1.61	*TACP*	Total area of land on which pre-project activities were displaced due to project activities	Field measurement	ha	m	Year 0	10% or at least 30 households	
3.1.62	$TACP_c$	Total area of cropland planted that is owned by community *c*	Field measurement	ha	m	Year 0	10% of communities (or at least 10), 10% of households per community or at least 10	
3.1.63	$TACP_h$	Total area of cropland planted that is owned by household *hh*	Field measurement	ha	m	Year 0	10% or at least 30 households	
3.1.64	*TNHH*	Total number of households using project lands in baseline	Field measurement	Dimensionless	Defined	Year 0	10% or at least 30 households	
3.1.65	$TNHH_c$	Total number of households inc community *c* using project lands in baseline	Field measurement	Dimensionless	Defined	Year 0	10% of communities (or at least 10), 10% of households per community or at least 10	

9. *Ex post* net anthropogenic GHG removal by sinks

The net anthropogenic GHG removals by sinks is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage, therefore, the following general formula can be used to calculate the net anthropogenic GHG removals by sinks of an A/R CDM project activity ($C_{AR\text{-}CDM}$), in t CO_2-e:

$$C_{AR-CDM} = C_{ACTUAL} - C_{BSL} - LK \qquad \textbf{(111)}$$

where:

$C_{AR\text{-}CDM}$ Net anthropogenic greenhouse gas removals by sinks; t CO_2-e

C_{ACTUAL} Actual net greenhouse gas removals by sinks; t CO_2-e

C_{BSL} Baseline net greenhouse gas removals by sinks (as pre-determined in the PDD); t CO_2-e

LK Leakage; t CO_2-e

Note: In this methodology equation 116 is used to estimate net anthropogenic GHG removals by sinks for the period of time elapsed between project start ($t=1$) and the year $t=t^*$, t^* being the year for which actual net greenhouse gas removals by sinks are estimated. This is done because project emissions and leakage are permanent, which requires calculating their cumulative values since the starting date of the A/R CDM project activity.

Calculation of tCERs and lCERs

To estimate the amount of CERs that can be issued at time $t^* = t_2$ (the date of verification) for the monitoring period $T = t_2 - t_1$, this methodology uses the EB approved equations,[29] which produce the same estimates as the following:

$$tCERs = C_{AR\text{-}CDM,t2} \qquad \textbf{(112)}$$

$$lCERs = C_{AR\text{-}CDM,t2} - C_{AR\text{-}CDM,t1} \qquad \textbf{(113)}$$

where:

tCERs Number of units of temporary Certified Emission Reductions

lCERs Number of units of long-term Certified Emission Reductions

$C_{AR\text{-}CDM,t2}$ Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_2$; t CO_2-e

$C_{AR\text{-}CDM,t1}$ Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_1$; t CO_2-e

10. Uncertainties and conservative approach

See Chapter 11.2. 'Quality control (QC) and quality assurance (QA) procedures to be applied to the monitoring process.

[29] See EB 22, Annex 15 <http://cdm.unfccc.int/EB/Meetings/022/eb22_repan15.pdf>.

11. Other information

11.1 Default values used in elaborating the new methodology

CF Carbon fraction of dry matter (IPCC default = 0.5); t C (t d.m.)$^{-1}$

GWP_{CH4} Global Warming Potential for CH_4 (IPCC default for the first commitment period =21 kg); CO_2-e. (kg CH_4)$^{-1}$

ER_{CH4} Emission ratio for CH_4 in biomass burning(IPCC default = 0.012); t CO_2-e (t C)$^{-1}$

CE Average combustion efficiency of biomass (IPCC default = 0.5); dimensionless

Sources of values: IPCC, 1996 Guidelines, IPCC GPG-LULUCF, GPG-2000 for energy, GPG-2000 for agriculture.

Some of these values are not used in this methodology; however, they may be used by users in adaptation of the methodology to specific local conditions.

11.2 Quality control (QC) and quality assurance (QA) procedures to be applied to the monitoring process

Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

- Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
- Identify and address errors and omissions;
- Document and archive inventory material and record all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. Higher tier QC activities include technical reviews of source or sink categories, activity and emission factor data, and methods.

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, should be performed upon a finalized inventory following the implementation of QC procedures. Reviews verify that data quality objectives were met, ensure that the inventory represents the best possible estimates of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme.

To ensure the net anthropogenic GHG removals by sinks to be measured and monitored precisely, credibly, verifiably and transparently, a quality assurance and quality control (QA/QC) procedure shall be implemented, including (1) collection of reliable field measurement; (2) verification of methods used to collect field data; (3) verification of data entry and analysis techniques; and (4) data maintenance and archiving. If after implementing the QA/QC plan it is found that the targeted precision level is not met, then additional field measurements need to be conducted until the targeted precision level is achieved.

11.2.1 Reliable field measurements

Collecting reliable field measurement data is an important step in the quality assurance plan. Persons involving in the field measurement work should be fully trained in the field data collection and data analyses. Standard Operating Procedures (SOPs) for each step of the field measurements shall be developed and adhered to at all times. These SOPs should detail all phases of the field measurements and contain provisions for documentation for verification purposes, so that measurements are comparable over time and can be checked and repeated in a consistent fashion. To ensure the collection of reliable field data,

- Field-team members shall be fully aware of all procedures and the importance of collecting data as accurately as possible;
- Field teams shall install test plots if needed in the field and measure all pertinent components using the SOPs;
- Field measurements shall be checked by a qualified person to correct any errors in techniques;
- A document that shows that these steps have been followed shall be presented as a part of the project documents. The document will list all names of the field team and the project leader will certify that the team is trained;
- Any new staff is adequately trained.

11.2.2 Verification of field data collection

To verify that plots have been installed and the measurements taken correctly, 10-20% of plots shall be randomly selected and re-measured independently. Key re-measurement elements include the location of plots, DBH and tree height. The re-measurement data shall be compared with the original measurement data. Any deviation between measurement and re-measurement below 5% will be considered tolerable and error above 5%. Any errors found shall be corrected and recorded. Any errors discovered should be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

11.2.3 Verification of data entry and analysis

Reliable estimation of carbon stock in pools requires proper entry of data into the data analyses spreadsheets. To minimize the possible errors in this process, the entry of both field data and laboratory data shall be reviewed using expert judgment and, where necessary, comparison with independent data to ensure that the data are realistic. Communication between all personnel involved in measuring and analyzing data should be used to resolve any apparent anomalies before the final analysis of the monitoring data is completed. If there are any problems with the monitoring plot data that cannot be resolved, the plot should not be used in the analysis.

11.2.4 Data maintenance and archiving

Because of the long-term nature of the A/R CDM project activity, data shall be archived and maintained safely. Data archiving shall take both electronic and paper forms, and copies of all data shall be provided to each project participant. All electronic data and reports shall also be copied on durable media such as CDs and copies of the CDs are stored in multiple locations. The archives shall include:

- Copies of all original field measurement data, laboratory data, data analysis spreadsheet;
- Estimates of the carbon stock changes in all pools and non-CO_2 GHG and corresponding calculation spreadsheets;
- GIS products;
- Copies of the measuring and monitoring reports.

Table G: Quality control activities and procedures

QC activity	Procedures
Check that assumptions and criteria for the selection of activity data, emission factors and other estimation parameters are documented	• Cross-check descriptions of activity data, emission factors and other estimation parameters with information on source and sink categories and ensure that these are properly recorded and archived
Check for transcription errors in data input and reference	• Confirm that bibliographical data references are properly cited in the internal documentation; • Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors
Check that emissions and removals are calculated correctly	• Reproduce a representative sample of emission or removal calculations; • Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy
Check that parameter and units are correctly recorded and that appropriate conversion factors are used	• Check that units are properly labeled in calculation sheets; • Check that units are correctly carried through from beginning to end of calculations; • Check that conversion factors are correct; • Check that temporal and spatial adjustment factors are used correctly
Check the integrity of database files	• Confirm that the appropriate data processing steps are correctly represented in the database; • Confirm that data relationships are correctly represented in the database; • Ensure that data fields are properly labeled and have the correct design specifications; • Ensure that adequate documentation of database and model structure and operation are archived
Check for consistency in data between categories	• Identify parameters (e.g., activity data, and constants) that are common to multiple categories of sources and sinks, and confirm that there is consistency in the values used for these parameters in the emissions calculations

QC activity	Procedures
Check that the movement of inventory data among processing steps is correct	• Check that emission and removal data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries; • Check that emission and removal data are correctly transcribed between different intermediate products
Check that uncertainties in emissions and removals are estimated or calculated correctly	• Check that qualifications of individuals providing expert judgment for uncertainty estimates are appropriate; • Check that qualifications, assumptions and expert judgments are recorded. Check that calculated uncertainties are complete and calculated correctly; • If necessary, duplicate error calculations on a small sample of the probability distributions used by Monte Carlo analyses
Undertake review of internal documentation	• Check that there is detailed internal documentation to support the estimates and enable reproduction of the emission and removal and uncertainty estimates; • Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review; • Check integrity of any data archiving arrangements of outside organizations involved in inventory preparation
Check time series consistency	• Check for temporal consistency in time series input data for each category of sources and sinks; • Check for consistency in the algorithm/method used for calculations throughout the time series
Undertake completeness checks	• Confirm that estimates are reported for all categories of sources and sinks and for all years; • Check that known data gaps that may result in incomplete emissions estimates are documented and treated in a conservative way
Compare estimates to previous estimates	• For each category, current inventory estimates should be compared to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain the difference

Section IV: Lists of acronyms and references

1. List of acronyms used in the methodologies:

Acronym	Description
AR	Afforestation and Reforestation
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CF	Carbon Fraction
DBH	Diameter at Breast Height
DOE	Designated Operational Entity
EB	Executive Board
GHG	Greenhouse Gases
GPG	Good Practice Guidance
GWP	Global Warming Potential
H	Tree Height
IPCC	Intergovernmental Panel on Climate Change
lCER	long-term Certified Emission Reduction
LULUCF	Land Use Land-Use Change and Forestry
NFS	Nitrogen Fixing Species
PDD	Project Design Document
QA	Quality Assurance
QC	Quality Control
RS	Root to shoot ratio
tCER	temporary Certified Emission Reduction

2. References:

All references are quoted in footnotes.

- - - - -

History of the document

Version	Date	Nature of revision
04	EB 50, Annex 17 16 October 2009	Application of the guidance covered by paragraph 37 of the report of the EB 44 meeting with respect to insignificant GHG emissions from selected sources related to A/R CDM project activities.
03	EB 42, Para 35 26 September 2008	Revisions mainly in the following sections: • *Section II. Baseline methodology* *7.2 Estimation of GHG_E (increase in GHG emissions by sources within the project boundary as a result of the implementation of an A/R CDM project activity)* *8 Leakage* • *Section III. Monitoring* Methodology 5.2 *Estimation of the increase in emissions* *7 Leakage* • To apply the guidance provided in para 35, EB 42 meeting report regarding accounting of GHG emissions in A/R CDM project activities, from the following sources (i) fertilizer application, (ii) removal of herbaceous vegetation, and (iii) transportation. The Board agreed that emissions from these sources may be considered as insignificant.
02	EB 36, Annex 17 30 November 2007	Inclusion of the guidance on the application of the definition of the project boundary in A/R CDM project activities, in accordance with decision 5/CMP.1.
01	EB 26, Annex 15 29 September 2006	Initial adoption.
Decision Class: Regulatory **Document Type**: Standard **Business Function**: Methodology		